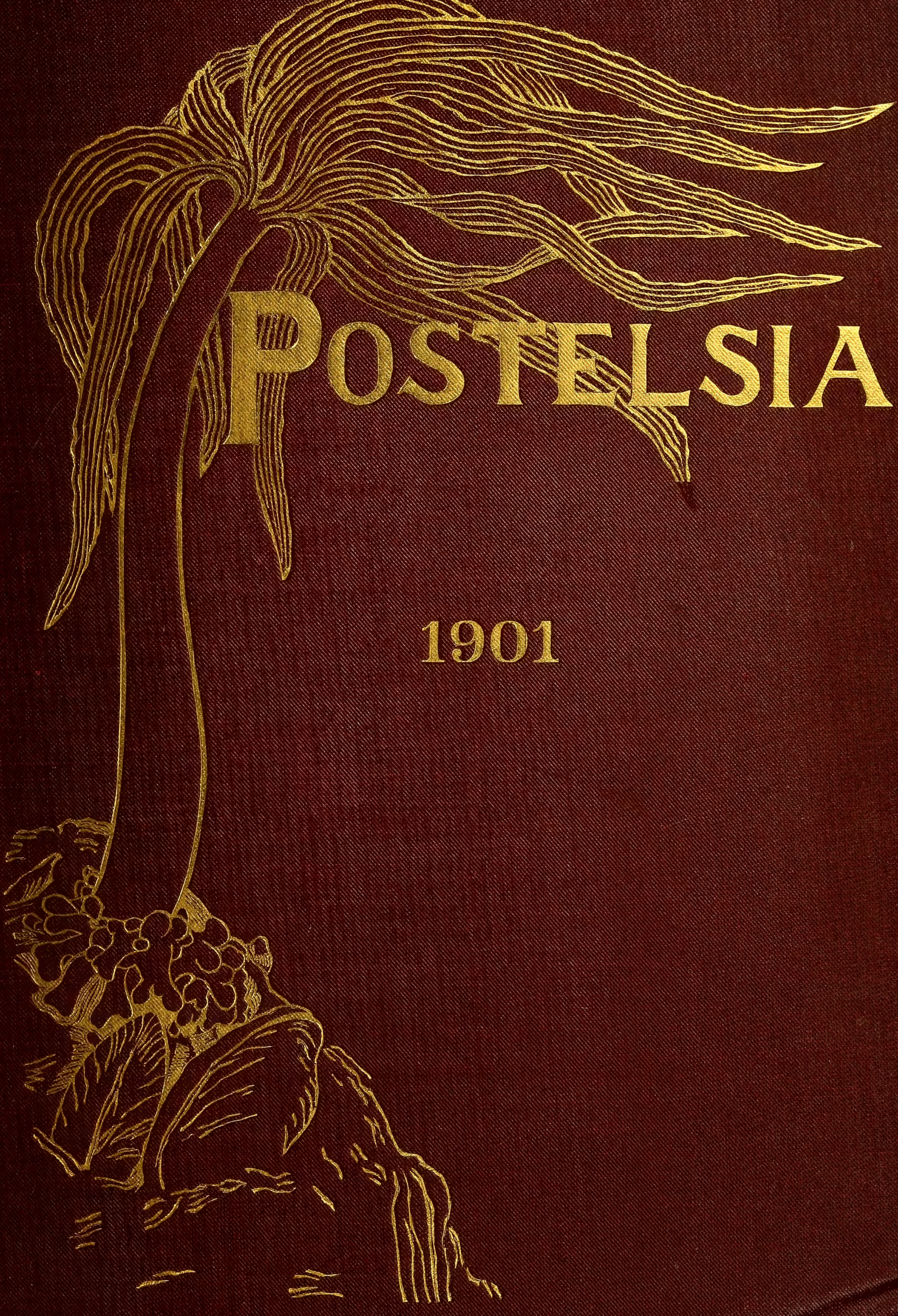

POSTELSIA

1901

Regulations for the Library

of the

Massachusetts Horticultural Society,

ADOPTED 1861.

ARTICLE I.

All Books, Manuscripts, Drawings, Engravings, Paintings, Models, Furniture, and other articles appertaining to the Library, shall be confined to the special care of the Committee on the Library.

ARTICLE II.

When any books or publications are added to the Library, a list thereof shall be posted up in the Library Room, and all such additions shall be withheld from circulation for the term of one month.

ARTICLE III.

The following Books of Record shall be kept:—

No. 1. A Catalogue of the Books.

No. 2. A Catalogue of the Manuscripts, Drawings, Engravings, Paintings, Models, and all other articles.

No. 3. A list of all Donations, Bequests, Books, or other articles presented to the Society, with the date thereof, and the name and residence of the donor.

ARTICLE IV.

Rare and costly books shall not be taken from the Library Room. A list of such works as are to be withheld from circulation shall be made out from time to time by the Library Committee, and placed in the hands of the Librarian.

ARTICLE V.

No more than two volumes shall be taken out by any member at one time, or retained longer than three weeks; and for each volume retained beyond that time a fine of ten cents per week shall be paid by the person so retaining it. And a fraction of a week shall be reckoned as a whole week in computing fines.

ARTICLE VI.

Every Book shall be returned in good order (regard being had to the necessary wear thereof with proper usage), and if any Book shall be lost or injured, the person to whom it stands charged shall, at the election of the Committee on the Library, replace it by a new volume or set, or pay for it at its value to the Society.

ARTICLE VII.

All Books shall be returned to the Library for examination on or before the first Saturday in July, annually, and remain until after the third Saturday of said month, and every person neglecting to return any Book or Books charged to him as herein required, shall pay a fine of twenty cents per week, for every volume so retained. And if at the re-opening of the Library, any Book shall still be unreturned, the person by whom it is retained shall pay for the said Book or set, as provided in Article VI, together with any fines which may have accumulated thereon; and a notice to this effect shall be forthwith mailed to him by the Librarian.

ARTICLE VIII.

No member shall loan a book to any other person, under the penalty of a fine of $1.00.

ARTICLE IX.

When a written request shall be left at the Library for a particular Book then out, it shall be retained for the person requiring it, for one week after it shall have been returned.

ARTICLE X.

Every book shall be numbered in the order in which it is arranged in the Books of Record, and also have a copy of the foregoing regulations affixed to it.

Postelsia
1901

Postelsia

The Year Book of the Minnesota Seaside Station

1901

A MA PUISSANCE
THE PIONEER PRESS
SAINT PAUL
MDCCCXLIX

St. Paul, Minnesota

1902

First Edition

Two Hundred and Fifty Copies


名産
昆布製菓子
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井 植田商店

The Contents


東海名産
御海苔
日本橋釘店
山形屋窪田惣八

Word of Introduction

The seven papers herein presented were first given before the members of the Minnesota Seaside Station during their season on the coast in 1901. While they are of the nature rather of fireside talks than of formal scientific lectures, yet it has seemed worth while to preserve them. To the members of the Station this little book will be a valued souvenir, recalling to their minds delightful days and nights beside the sea. To others, as a collection of botanical e s s a y s, or as a document from the youngest of the American marine biological stations, it may not be altogether without interest.

Uses of Marine Algae in Japan

Uses of Marine Algae in Japan

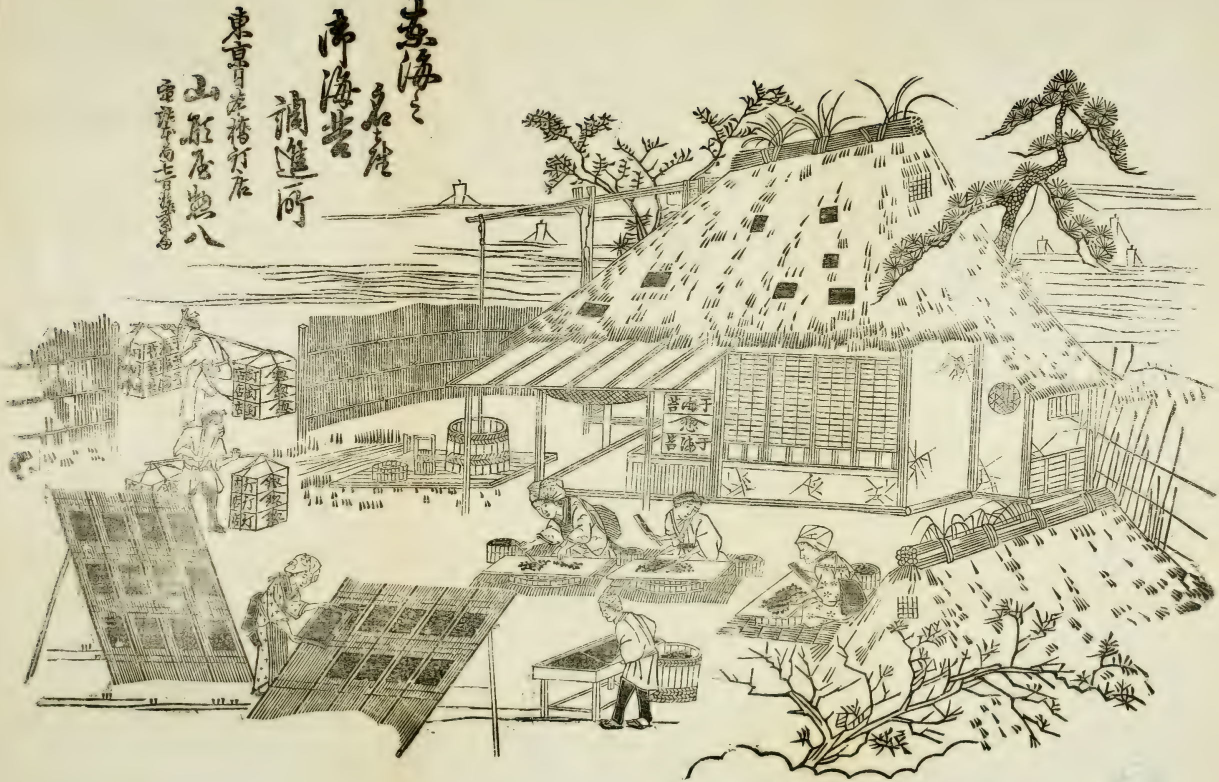
K. Yendo

Japan consists of a group of narrow islands with the interior rough and mountainous. Owing to the irregularity of the surface, the coast line is very long and a large share of the population is brought in contact with the sea. Under these circumstances they have learned to make economic use of many marine algæ. I propose to mention briefly the more important algæ which are generally used by the inhabitants of Japan. It is not my intention at this time to describe the plants of more restricted use. I have given in each instance the international, followed by the Japanese, name and a short statement of the particular economic importance.

Ulva lactuca (Aosa). This is called green laver by the English, and is abundantly made use of in Japan as a garnishment for salads and fish. It is particularly prized as a table decoration and is used very much as the English and Americans employ lettuce or parsley.

Enteromorpha linza and *intestinalis* (Awonori). The *Enteromorpha* plants are collected and dried in the sun either in the form of bunches or sheets. The dried plant is baked slowly over a charcoal fire and is afterwards powdered. In this condition it is used as a condiment and to flavor the sauces of meat and fish. It gives a peculiar savor and is principally used by the peasantry.

Codium mucronatum and *lindenbergii* (Miru). After collection these plants are bleached in fresh water and dried in the sun. To prepare them for food

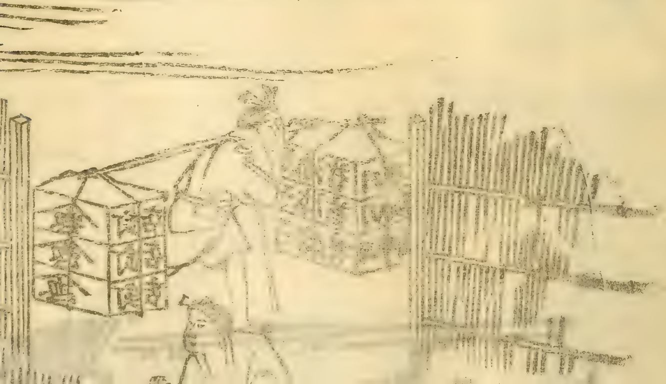

東海之名産
御海苔
調進所
山形屋忠八

金聲玉振閣藏

山紫水明人

東京日本橋通二丁目

開進堂



they are boiled or sometimes baked. Their use is not very common.

Phyllitis fascia (Haba-nori). Young plants of this species are collected and laid out in sheets after a method which will be explained more in detail in connection with the uses of *Porphyra*. The sheets are dried in the sun and afterwards baked, powdered and eaten with soy.

Haba-nori is used principally by the peasantry of the Province of Awa and Sagami.

Chordaria abietina (Matsumo). This is particularly abundant in northern Japan, where it is collected and packed in salt. It is cooked with soy and is a common food of the poorer classes in the north. It is also employed in the preservation of mushrooms, which are washed with fresh water and layered in tight barrels in which the salted seaweeds are preserved.

Mesogloia decipiens (Mozuku). Like *Phyllitis*, this is collected while young. It is preserved in salt, and when ready for use thoroughly washed in fresh water and eaten as a salad with vinegar. Its use is general all over Japan.

Undaria pinnatifida (Wakame). This species is used in several ways. Dried bales are common articles of merchandise. After washing with fresh water it is used as an ingredient of soup, cooked with soy, or eaten as a salad with vinegar. *Alaria esculenta* is similarly used by the Scotch and Irish. The peasantry of northern Japan cut off the ripe sporophylls of *Undaria* and press them into a slimy liquid with a peculiar and distinctive odor. This they mix with boiled rice. I have tried to eat this mixture, but without success.

Laminaria (Kombu). Several species of the genus are important articles of food for the Japanese and are exported to China, the business amounting to several hundred thousand yen each year. The *Laminaria* fishermen use long poles with forks or sickles at the end. With these they wind up the long laminæ—sometimes forming belts a hundred feet in length and two feet in width—down to the point of attachment, when the plant is either pulled from the rocks or cut off just above the holdfast. The laminæ are then dried in the sun on the sand beach, packed in bundles and bales and shipped to the markets. The two most important species commercially are *L. japonica* (Shinori-kombu) and *L. angusta* (Mitsuishi-kombu). The former is broad, long and thick when folded; the latter narrow, short and stiff and prepared in bundles, not in bales. The smaller variety is used in confectionery, while the larger is made into a tea

(Kombu-cha), boiled in soup or cooked in a variety of ways. One form in which *Laminaria* is very much relished by the common people is the so-called Kombu-mati or *Laminaria* roll. To make this, the dried weed is boiled in fresh water for a while and cut up into pieces of the desired length and width. Portions of dried herring, cod or other fish are wrapped up in the boiled alga and then recooked in dilute soy, soup or milk. *Laminaria* is also used upon New Year's day as a festoon, and for this purpose *L. radicosa* (Antokume) is utilized, but not as a food.

Ecklonia bicycles (Arane). This is used by the peasants in the same way as *Undaria* and as a decoration. *E. cava* (Kajine) has no food use, but is an important decorative plant.

Cystophyllum fusiforme (Kijiki). The young fronds are collected and dried in the sun, in which condition they are a well-known article of merchandise. Cooked in soy it is eaten by the peasantry, but not by the better classes.

Sargassum (Moku or Mo). More than a dozen species of this genus are found along the Japanese coast as inhabitants of the sub-littoral region in middle and southern Japan. The plants are collected, dried and used as fertilizing material. One species, *S. enerve*, takes an attractive green color when dried, and on New Year's day is intertwined with *Laminaria* in the decorations of the home. These plants occupy much the same place in Japanese life that the holly does among the English.

Porphyra (Asakusa-nori, amanori or nori). This is one of the most important food plants of Japan. It is used by every class of people in a variety of ways and is cultivated in many districts. The plant is collected, made into sheets and baked. The method of cultivation is as follows: Slender, bushy twigs are planted in regular rows in shallow and brackish water. Enough space is left between the rows to permit the passage of canoes. Late in winter or early in spring the *Porphyra* plants gather on the twigs as purple leaf-like sheets between tide marks. The tiny pieces are collected with wonderfully expert fingers, most of the work being done by girls or women. They are washed for a time to remove the mud and sand and are then laid out upon reed mats which are placed in the sun. The layer is made as thin as possible, the plants adhering to each other by their own gelatine. When such a sheet is quite dry it is peeled off from the surface of the mat, folded and ready for market. When baked before a gentle fire, *Porphyra* acquires a remarkably agreeable flavor; the rule of the cooks is to bake until the purple color changes to green. After cooking, *Porphyra* is eaten with soy, powdered and employed as a condiment or made up into sushi. This occupies somewhat the same place in the Japanese menu as the sandwich does in Europe and America. A sheet of *Porphyra* is laid out, boiled rice spread upon it, strips of meat or fish laid upon this, and the whole then rolled up. after which it is cut in slices. Everyone eats sushi.

Nemalion lubricum (Umi-zomen). In some parts of Japan this plant is dried and bleached. It is then eaten with soy or vinegar, but its use is not common.

Gelideum corneum (Ten-gusa). Next to *Laminaria* and *Porphyra* this is perhaps the most important alga in the list of economic species. From it the agar-agar of commerce is manufactured. The plant is dried and bleached and taken to the markets. In the agar-agar factories the raw material is boiled in water and converted into a semi-transparent, glue-like liquid, which is allowed to cool in the air. This fresh agar-agar, called Ten by the Japanese, is a favorite summer dessert. In the winter the Ten is prepared in large shallow boxes, cut into long blocks and frozen, in which condition it is known as Kan-Ten. It is used in confectionery and has also its use in the bacteriological laboratories of the world as a culture medium. One defect of agar-agar in the last named use is its opacity. Methods of electro-bleaching have been devised by one of my friends, which will perhaps obviate this difficulty.

Chondrus crispus, *elatus* and *ocellatus* (Tsuno-mata, Hosokeno-mimi). These plants are dried in the sun and are afterwards boiled up into a starch for linen

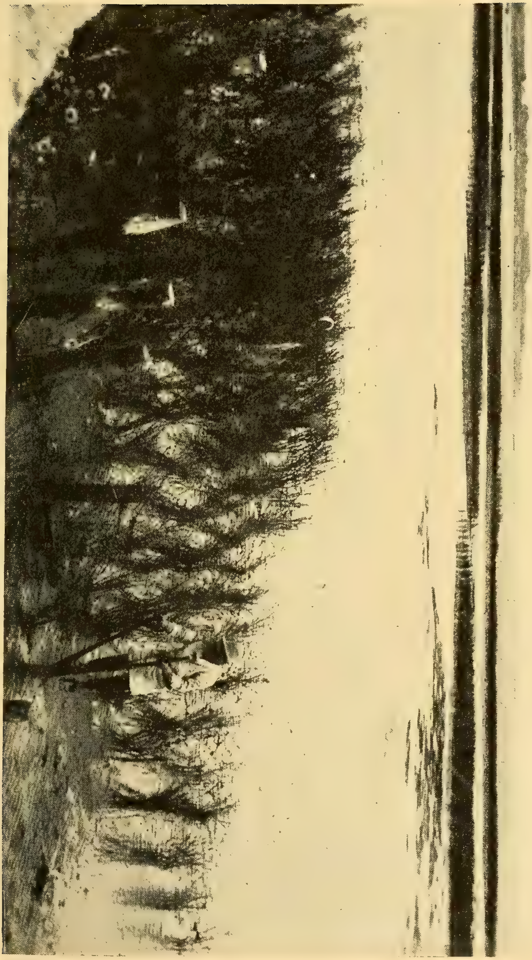


PLATE I. — Planting Twigs for Porphyra.

or used as a washing compound. The solution is supposed to have a cleansing value, but what it may be is not yet very clear. *C. ocellatus* has been employed by one of the assistants in the Tokyo medical college as a material from which to manufacture agar-agar, upon which pure cultures of amœba have been developed. *C. elatus* is a food plant of the peasantry in northern Japan.

Gigartina teedii (Catanori). This and some other species of the genus are occasionally cooked, but their use is not general.

Gymnogongrus flabelliformis (Okitsu-nori). This plant, with its varieties, is used as a table garnishment and for sauces. It is first dipped in hot water to dissolve the phyco-erythrin and used after it has turned green.

Sarcodia sp. (Tosaka). This beautiful red plant, the species of which has not yet been determined, is a favorite food of the fishermen in middle Japan.

Gracilaria confervoides (Ogo-nori). The plants are treated with lime-water or dipped in hot water to change the color from pink to green, after which they are used as garnishments. This is a favorite variety in the city of Tokyo.

Digenia simplex (Makuri). A product of southern Japan, this plant is dried and sold by the apothecaries. Its extract has been generally regarded as a valuable infantile remedy, but it is not so popular a remedy as formerly. It holds its own in the provinces and is regarded by the country people as the Europeans did *Corallina officinalis.*

Campylæphora hypnoides (Ego). This is prepared similarly to *Gelideum corneum.* It makes a stiff jelly, which is used for food with sugar or soy, much as is cornstarch by the Americans.

Gloiopeltis calliformis (Funori). This species, with others of the genus, is occasionally used as a food, being cooked in soup. Its more ordinary use, however, is as a starch for clothes. The plants are bleached, boiled a little and then dried in sheets. These are bought in the markets by the housewives and boiled up again in fresh water. A gelatinous liquid is thus extracted, which is diluted. The clean linen is dipped therein, dried and ironed.

Grateloupia affinis (Comenori) and *G. filicina* (Mukade-nori). These plants are dried, and after dipping in fresh water are eaten with vinegar or soy. Their use is not very general.

The above will serve to give an idea of the extent to which algæ are utilized by the Japanese. I add herewith the export statistics for leaf laminaria, cut laminaria and agar-agar for the period from 1890 to 1894. China is the principal customer of Japan for these algæ and algal products.

Export.

(Chiefly for China.)

LEAF LAMINARIA.

1890......	26,769,764	lbs.	563,504	yen
1891......	26,356,521	"	618,925	"
1892......	36,713,303	"	818,841	"
1893......	32,718,468	"	766,573	"
1894......	35,851,245	"	467,235	"

CUT LAMINARIA.

1890......	6,072,560	lbs.	148,492	yen
1891......	5,080,462	"	116,106	"
1892......	6,498,297	"	175,785	"
1893......	6,935,038	"	172,846	"
1894......	5,999,134	"	139,793	"

AGAR-AGAR.

1890......	1,026,624	lbs.	323,444	yen
1891......	1,200,239	"	453,124	"
1892......	1,269,202	"	581,218	"
1893......	1,452,728	"	682,140	"
1894......	1,298,422	"	495,625	"

PLATE II. — Bales of Laminaria for Export to China.

The amount of the algæ consumed in the home country is not exactly known. It is only known that the number of the *Porphyra* sheets manufactured in the year 1894 amounted to 11,232,900. As *Porphyra* is rarely exported abroad, this whole amount should have been spent in a year.

The following is a description of the three Japanese prints that accompany this paper: The colored print with the gilt scroll and foreground represents the Ainu people gathering Kombu (*Laminaria*). This is from Hakodate and is the actual cover of a Kombu cake. The other colored print represents a girl going out with a bamboo basket to collect Nori (*Porphyra*); the "brush-garden" is seen in the background. The uncolored print shows the process of Nori manufacture; three girls are engaged in cleaning the plant; a boy is making it into sheets; another girl is stretching the sheets upon a reed screen to dry them. Two coolies are carrying away the packages which are ready for shipment. This print is the commercial wrapper used by S. Kubata, of Tokyo, and it has been thus employed in his family for two hundred years.

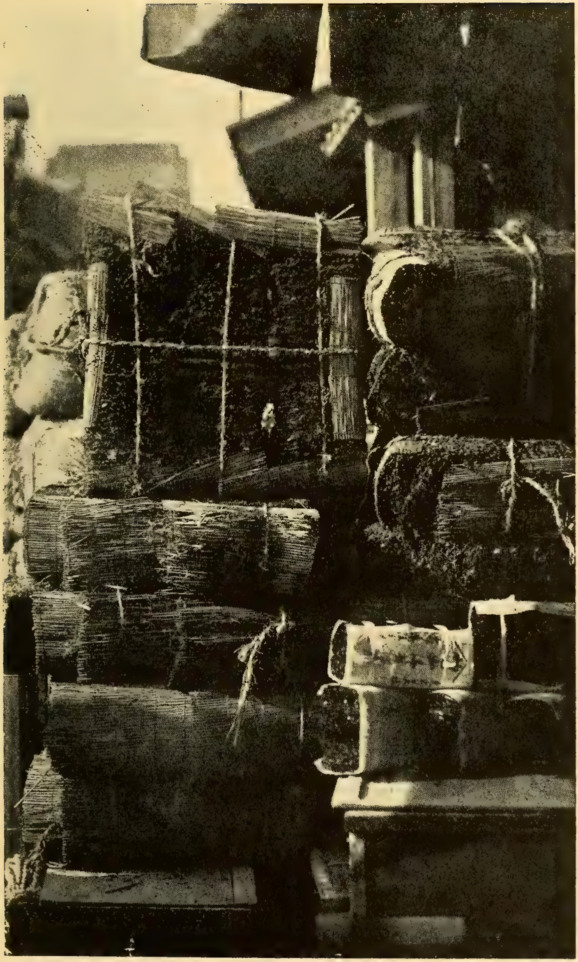


PLATE III. — Commercial Packages of Enteromorpha.

Remarks on the Distribution of Plants in Colorado East of the Divide

PLATE IV.—A Colorado Mountain Lake.

Remarks on the Distribution of Plants in Colorado East of the Divide

FRANCIS RAMALEY

To understand the character of the vegetation on the eastern slope of the Rocky Mountains it is necessary to know something of the climate. It may be said at the start that this is an arid region. The annual rainfall on the plains and in the lower foot-hills is about 30 cm. This is not evenly distributed throughout the year, but about one-half of the total precipitation occurs in the spring months. The summer, autumn and early winter are very dry. Occasional local showers in summer or snow-falls in autumn are not enough to lay the dust. In the high altitudes there is, however, somewhat more moisture than on the plains. The prevailing winds are from the west. They cause a rapid drying up of moisture, for they are warm and dry. The sun shines brightly most of the time. Cloudy days are rare, except at the time of the spring snows in April or May.

Deciduous trees will not grow without irrigation except in the creek bottoms and narrow canons. The plains are covered with plants which show special adaptations to meet the peculiar conditions of climate. There are the succulent cactuses, the hairy sage brush and species of *Astragalus*, the well protected Yuccas. With many plants the growing season is very short; thus the sand lily (*Leucocrinum montanum*) appears first above ground the latter part of April. It soon flowers and develops fruit, and by the middle of June the above-ground parts of the plant have withered completely. By July the prairie grasses have turned to hay. The summer and autumn bring forth few plants except among the hills, where the growing season is much later than on the plains.

Plants of roadsides and waste places. The visitor to Colorado who may be interested in plants is likely to be surprised at the great number of familiar weeds to be seen in vacant lots and neglected places in cities and towns. Everywhere east of the divide, at altitudes not greater than 1,700 meters, many of the commonest plants are identical with those of the states farther east. One may see in early spring the dandelion, shepherd's purse, peppergrass and *Lappula* and later in the season the round-leaved mallow, sweet clover, barnyard grass, pigeon grass, species of *Poa,* red clover, plantain and Russian thistle. In dry places occur numerous prostrate species, such as *Verbena bracteosa*, purslane, knot-grass, spurges and species of *Amaranthus*. In moist places such plants as *Rumex* and *Polygonum* abound, and with them numerous sedges. Among the late flowering plants are the prickly lettuce, dog-fennel, ragweeds, tall flea-bane, asters, *Iva*, sunflowers, cone-flowers and cockleburs.

The plants just named are widely distributed. They form an important part of the flora not only of eastern Colorado, but of the Mississippi basin generally. Some are the common introduced plants known everywhere in eastern North America, some are natives of the Eastern States which have migrated westward with man, some are western representatives of genera well known by other species farther east.

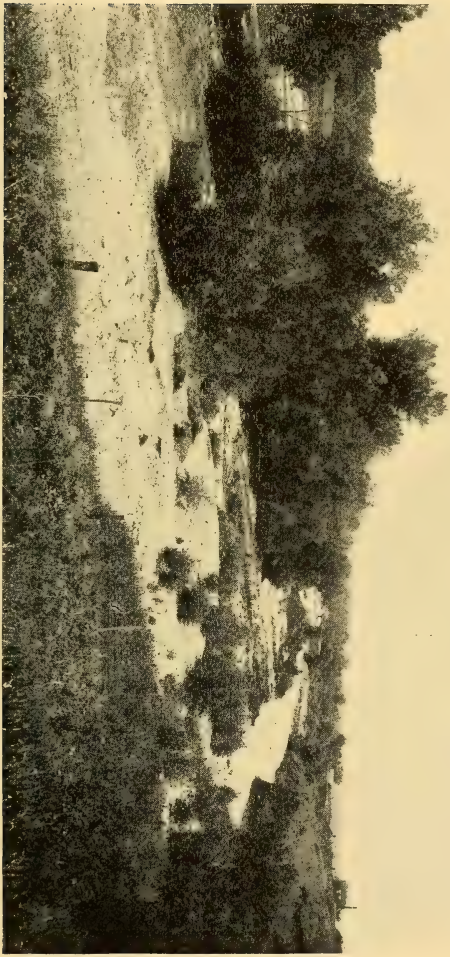


PLATE V.—A Dry Creek Bottom.

Besides the plants named there are many to be noted which are more or less distinctly western. The Mexican poppy (*Argemone*) is perhaps the most conspicuous roadside plant of the region. The large white flowers first appear in May and the plants often remain in blossom all summer. *Gaura coccinea*, various evening primroses and the species of *Mentzelia* are conspicuous. Alfalfa, (*Medicago sativa*), which is cultivated in this region as a forage plant, has escaped to the roadsides, and its dark green foliage and somewhat somber bluish flowers are everywhere seen. In early summer one may see an abundance of yellow flowers, *Sophias*, and in the autumn *Grindelias* of the same color brighten the waste places. Of the *Gramineæ* the numerous western species of *Bouteloua*, *Agropyron* and *Stipa* should be mentioned together with such individual species as *Andropogon halii* and *Sitanion brevifolium.* Probably the most striking plants of midsummer are *Cleome* and *Euphorbia marginata.* Of the plants of less conspicuous appearance *Solanum rostratum* and other species of *Solanum*, *Salvia lanceolata*, *Chenopodium ambrosioides* and the everywhere abundant sage bush (*Artemisia spp.*), make up a considerable portion of the ruderal flora. The zonal distribution of roadside plants is well illustrated in many places, especially where there is an irrigating ditch at the side of the road. This serves to keep some considerable space moist while the other parts of the road are very dry. The distance through which the water of the ditch seeps varies with the character of the soil but there can almost always be recognized an intermediate zone between the wet and dry places. Plants which commonly grow in dry soil are certain prostrate species as previously mentioned, also some species of *Agropyron*, *Sitanion*, *Grindelia*, *Artemisia* and prickly lettuce. In the slightly moist places may be the Mexican poppy, alfalfa, *Cleome*, *Euphorbia marginata* and ragweed. In the ditches and pools occur the common green and blue-green algæ, the arrowheads, water plantains and watercress. On the ditch banks there are sedges and grasses with species of *Roripa*, *Rumex*, *Polygonum* and *Bidens*. Some species are able to establish themselves in all the three zones mentioned; perhaps the best example is found in the dandelion, which is almost universally distributed. Sometimes the plants mentioned above as occurring in the drier places may succeed in getting a foothold in the more favored soil, but it is seldom that the other plants are able to make themselves at home in the dry and dusty highway. Many roadside plants occur in great abundance. When the dandelions are in full bloom, one may look up a street in many a country town and see two broad golden bands flanking the roadway and giving the scene a wonderfully gay aspect. This great profusion of individuals at certain seasons and in given localities causes striking changes in the landscape. Within a stone's throw of a compact yellow field of dandelions may be a group of Mexican poppy (*Argemone*), with its showy white flowers and dusty green foliage. In midsummer the sunflowers line the railroad grades, while early in September the country roads for miles show bands of white on either side due to *Euphorbia marginata*, or in other places they are pink with a profusion of the tall and beautiful *Cleome.*

PLATE VI.—1. Roadside Group of Argemone.
2. Senecio on Mesa, looking Westward.

The plants growing at the sides of the lower mountain roads are generally the same species as are found on the plains. As higher altitudes are reached, however, the number of characteristic roadside weeds diminishes. The following plants generally thin out or completely disappear at the altitude named: *Euphorbia marginata* 2300 meters, *Cleome* and prickly lettuce 2400 meters, Mexican poppy 2500 meters, *Grindelia* and *Iva* 2600 meters, plantain and shepherd's purse 2700 meters. The figures just given are correct only in a very general way, since the distribution of these plants is determined not only by climatic and edaphic conditions, but also by opportunities for the dissemination of seeds. In the town of Ward, one of the oldest mining camps in the State, where there has been a good opportunity for distribution of weeds, the plants met with in the streets are nevertheless chiefly mountain species. There are also some few plants which have come up from lower altitudes. A list of plants of waste places made in late summer in such a locality would include *Physaria didymocarpa*, *Gilia inconspicua*, *Achillæa lanulosa* and various species of *Rumex*, *Polygonum*, *Potentilla*, *Artemisia*, *Aster*, *Hordeum* and *Grindelia*. The prickly lettuce and shepherd's purse occur sparingly. All of these plants are so few and far between that one may almost say that there are no weeds in high altitudes.

Plants of the Mesas. The mesas are long, gently sloping, flat topped ridges extending from the bases of the foothills out towards the plains in an easterly direction. They consist usually of rock debris more or less decomposed. The vegetation on the north slopes of the mesas differs, more or less markedly, from that of the south slopes. The varying amount of moisture and sunshine are the important factors in determining this difference. The east and west ends of the mesas are also different in their plants. The west end, being closer to the foothills, is sheltered from the afternoon sun, while the east end is not thus protected. In the spring, small streams from the melting snow on the hills water the west end of the mesa. The snow also lies longer there. Pine trees and quaking asps grow there, while at the east there are no trees at all.

If one travel westward on one of these mesas a distance of one or two kilometers in the spring of the year he sees a gradual transition from the xerophytic formation of cactuses, *Yucca*, *Astragalus*, sage brush and desert grasses to the semi-xerophytic pine groves with their *Pulsatillas* and larkspurs. The shrubs *Cercocarpus*, *Ribes*, *Edwinia* and the skunk bush (*Rhus trilobata*) grow among the pines or east of them for a distance. The last named shrub is abundant on the north slopes of mesas, even well out from the hills. If one look westward from the plains into the ravines between two adjacent mesas, the south side of the ravine, i. e. the north slope, will be seen well covered with skunk bush, while there are but few of these plants on the south slopes.

Sometimes a mesa will have certain shrubs growing near the top on the south slope, but none farther down on the same slope. Since it is moisture chiefly which determines the distribution of the shrubs, this may seem

PLATE VII. — 1. Pasque Flowers on Mesa.
2. A Thimble-berry in Lower Foot-hills.

odd, for it would be expected that the top of the slope would be the driest place of all. It is so in most hills. The mesas, however, have flat tops, on which the spring snow lasts for a long time. As it slowly melts, the water trickles down the sides and is absorbed by the soil not far from the top of the slope. There is sufficient moisture on the north slope to permit the growth of shrubs for some distance away from the foothills. In general the tops and the north sides of the mesas ave the same plants. At the eastern end of mesas the north and south slopes are quite gentle. Here the plants are alike on the slopes and on the top which becomes the east slope at the terminus of the mesa. All the plants now are species of the plains.

The flora of the mesas is a complex of mountain and plain species.

Together with the lower foothills the mesas form the battle ground where is waged the war between the highland and the lowland plants. At one season of the year the vegetation of the mesas has the character of the mountain region. At another season the prairie plants are more abundant. The changes may take place with almost kaleidoscopic speed. The slight change in the angle of the sun's ays replaces the white flowered prairie sand lily (*Leucocrinum*) with the blue *Pentstemon* or larkspur of higher altitudes. Later the prairie *Yucca* comes into blossom, and then there appear great yellow masses of *Arnica*, the near relatives of which belong to the higher altitudes. Then come again prairie plants, the wall flower *Erysimum* and the yellow puccoon (*Lithospermum*). Soon appear the white and purple prairie clovers (*Petalostemon spp.*) and the sunflowers. With the coming on of autumn the mesas are green with the herbage of *Senecio* and *Gutierrezia*, which, as they come into blossom, impart a yellow tinge to the entire landscape. These two dominant species of the herbaceous flora of autumn have arrived from different regions. The *Senecio* (sp. undet.) occurs regularly in the mountains at higher levels, while *Gutierrezia* is properly a plant of the plains, and in northern Colorado does not ascend into the mountains at all.

The Plants of the Lower Foothills. These resemble those of the mesas. Similiar conditions of moisture and heat prevail. For the most part the lower foothills are sparingly covered with pines. The north slopes of hills are better provided with trees than the south slopes. Spruces and cedars are found in the gulches. Quaking asps form small clumps and patches in slightly moist soil. The narrow leaved poplar, the cottonwood, chokecherry, alder and various willows find places along the streams. The mountain maple (*Acer glabrum*), *Opulaster*, alder, Juneberry, *Edwinia*, *Cercocarpus* and *Ribes* occur on the hillsides in various situations. One of the first plants to flower in the spring is the Oregon grape (*Berberis aguifolium*), a low woody plant whose leaves remain green throughout the winter. The herbaceous plants are chiefly those previously mentioned as occurring on the mesas or to be mentioned later in discussing the mountain parks. The foothills, like the mesas, vary much with the different seasons. Beautifully green after the spring snows, they remain of this color for a month or two, when

Postelsia

PLATE VIII.—1. View on Top of a Lower Foot-hill.
2. Scene in a Mountain Park.

the failing rain lets them wither to yellow or brown. If one be among the hills, many minor changes of color are to be seen. The pale blue *Pulsatillas* are followed by yellow wall flowers and *Physarias*, these, as summer draws on, by pink *Phloxes*, blue *Pentstemons*, the yellow *Thermopsis*, pink *Geraniums*, purple *Erigerons* and *Lacinarias* and yellow *Senecios*. Perhaps the most beautiful and striking plants of the lower foothills are the *Eriogonums*, such as *E. umbellatum* and *E. hallii* with large umbels of yellow flowers. Whole hillsides, at one time blue with *Pentstemon*, shine forth soon after with the brilliant lemon yellow hue of *Eriogonum*.

In the canons and gulches of the foothill region the hackberry, box elder, poplar, sumac, gooseberry (*Ribes spp.*), poison ivy (*Rhus rydbergii*), *Edwinia*, thimbleberry (*Rubus deliciosus*), alder, dogwood, rose and hazel are the most noticeable woody plants aside from the coniferous trees. The pines occur almost everywhere, spruces and cedars in moist places and junipers only on dry hillsides.

Although one can thus mention a large number of deciduous trees and shrubs they have very little influence in determining the appearance of the landscape, except late in the season, when their brilliant autumnal colors enforce our attention to them. The dominant woody plants are certainly conifers. They stamp their individuality upon the entire plant community.

It may seem strange that no mention has been made thus far of mosses, liverworts and ferns. These plants are represented by only a very few species and comparatively few individuals.

Marchantia and one or two other thalloid liverworts, a few mosses and a few leafy liverworts are scattered sparingly here and there in moist and well shaded places. It is a rare thing to see a well developed mat or carpet of moss larger than a man's hand. During the wet season a few mosses are rather abundant on exposed rocks. Their season for growth is very short, perhaps a month or six weeks. Then they become dried up and do not grow again until the following year. The horsetails are represented by only two or three species and these are not at all abundant. One needs to know a locality well in order to be able to find enough of these plants for class work. *Woodsia*, *Cryptogramma*, *Asplenium* and *Pteridium* are met with in moist situations, but, as moist situations are not common, these ferns are by no means common. Species of *Selaginella* find a foothold on exposed eastern slopes. Their distribution is very uneven on different hills. Some hills have an abundance of individuals, while others have very few or none at all.

Fungi are everywhere scarce. There are very few agarics to be found anywhere among the lower hills or on the plains. Puff balls are seldom seen; shelf fungi are almost unknown. A few æcidia in the spring, and certain rusts, mildews and blights in late summer, form the principal part of the fungus flora.

Of all the lower plants the lichens are of most interest. *Cladonia*, *Usnea* and *Peltigera* are not uncommon on stumps and logs, but the rock lichens are a source of perennial joy to all who ramble among the hills. Every rock has its patches of olive, pale green, yellow, red or brown lichens. Sometimes a huge boulder is completely covered with lichens of one color, or it may be mottled with irregular markings of various colors. In the canons vertical walls of granite are streaked with orange, green and red. Great areas of solid color, many meters in diameter, delight the eye. A trip through a narrow canon reveals the most marvelous color effects at every turn of the road.

Plants of the Mountain Parks and Higher Foothills. The mountain parks are somewhat level stretches of land shut in on all sides by high mountains or hills. They vary from a few to very many square kilometers in extent. The altitude of these parks in the region being considered is usually from 2,500 to 3,000 meters. Plants to reach these parks from below must make their way up narrow canons or else over the passes, which may be from 200 to 500 meters higher than the parks themselves. This peculiar situation of the parks leads to a paucity of plants from lower altitudes and an abundance of more peculiarly mountain forms. On account of the somewhat greater rainfall, there is a nearer approach to mesophytic conditions than in the lower foothills. Many plants which, at lower altitudes, seek the protection of narrow gulches are here able to thrive in the open. The blue columbine (*Aquilegia cœrulea*), one of our most conspicuous and well known plants, is quite abundant in many places.

In the parks there are generally some small stretches of meadow land along the streams with abundant growth of sedges and grasses. Willows, poplars and alders fringe the creeks and ditches.

Pentstemon secundiflorus and the mariposa lily may occur in these moist places. The beautiful shrub *Dasiphora fruticosa* is found here, although often growing in much drier places. The fire weed (*Chamanœrion*) sometimes occurs in great abundance. On shaded creek banks grow a few agarics, and here and there leafy liverworts find place on a fallen log or dead stump. A few mosses occur here too, and thallose liverworts, especially *Marchantia.*

It must not be supposed that the mountain parks have a characteristic flora of their own. It is the flora of the foothills of the same elevation merely modified by conditions of distribution and slight physiographic peculiarities.

In these parks and on the surrounding foothills, the coniferous trees are the dominant plants, although here are found also many groves of small quaking asps no larger than apple trees. The coniferous trees do not usually form dense forests, except occasionally on certain hillsides. The parks are for the most part rather open, permitting the development of a grass flora. With the grasses, especially along rocky ledges, there are many profusely flowering perennials, such as harebells (*Campanula spp.*), *Eriogonum spp.*, *Allium spp.*, species of *Aster*, *Erigeron* and *Pentstemon*, besides the plants named in the previous paragraphs.

When a given species of plant has a wide vertical distribution a single trip to the mountains will show it in every stage of development. In the lower altitudes it may be in flower or fruit, higher up in bud, and still higher barely starting from the ground. If, for example, a collector be anxious to ob-

PLATE IX. — 1. Leucocrinum, the Sand-lily.
2. Effect of Wind at High Altitudes.

tain the columbine and he allows the time of flowering in the lower hills to pass by, he may still, two or three weeks later, get the plants in prime condition by climbing to an altitude of 2,500 meters or more.

Plants of Very High Altitudes. It is only in the sub-alpine regions, at an altitude of about 3,200 meters, that distinctly mesophytic conditions prevail. Where the timber has not been cut or burned, the shade permits the snows to lie until June or July. The ground may be quite wet all summer. Summer showers are frequent. Considerable areas of swampy ground occur at the bases of the high mountain peaks. There are also many ponds or small lakes. In wet places there are sedges and some marsh grasses. *Polytrichum*, *Funaria*, *Sphagnum*, and other mosses are found where conditions are favorable. There are some fleshy fungi. Of plants with conspicuous flowers the following may be mentioned: *Moneses uniflora*, *Kalmia glauca*, *Pyrola spp.*, *Pedicularis spp.*, *Pentstemon spp.*, *Elephantella grœnlandica*, *Castilleja spp.*, *Linnæa borealis*, *Mertensia sibirica*, *Sedum rhodanthum*, *Primula parryi*, *Polygonum bistortoides*, *Gentiana spp.* Nearly all the species and some of the genera are quite strange to one who is familiar only with the plants of the lower foothills.

Snow covers the high peaks, except where these are very precipitous, until late spring. Often large snow fields remain the year round. The upper limit for the growth of trees on the mountains of northern Colorado is about 3,700 meters. In some places it is lower, in some places higher.

This upper limit is commonly called the "timber line." There is no definite "snow line;" this changes with every storm or with every sunny day.

The trees in the higher regions show the effect of wind to a pronounced degree. The winds blow mostly from the west and the trees assume a very one-sided appearance. Near timber line they are all very much dwarfed and gnarled.

The mountain tops are made up of rocks, either in large masses, or broken up by the action of frost into irregular boulders. There is but little gravel or soil in which plants might find place. Nearly all the plants of the peaks occupy crevices or other sheltered places.

Above timber line there are almost no woody plants, although a few willows less than a decimeter high are found on the highest peaks. Of the truly alpine plants mention may be made of the following: *Silene acaulis*, *Arenaria sajanensis*, *Dryas octopetala*, *Mertensia alpina*, *Polemonium confertum*, *Phacelia glandulosa* and species of *Saxifraga*, *Draba* and *Erigeron*.

Concluding Remarks. What has been said of the distribution of plants in Colorado refers entirely to that part of the State east of the front range and drained by the South Platte river. In crossing the range to the west, a new flora is encountered, and in passing the divide which separates the drainage areas of the Platte and the Arkansas, many southern plants are met with.

An attempt has been made to indicate in very general terms the nature of the plant population in different situations. Plants of the plains have not been discussed fully, but many are mentioned in the accounts of roadside plants and plants of the mesas. The plains are more or less well known to everyone who has lived in the Mississippi basin, for the plains are merely exaggerated prairies, larger and drier than the prairies of the north central states, but otherwise very similar.

Where the plants of the plains meet the mountain forms on the foothills and mesas, there is a mixed flora, rich in species both of western and more eastern genera. Few of the plains plants ascend to any great altitude, and few mountain forms make their way far out on the plains. The *Yucca* and certain cactuses of the plains may reach an altitude of 2,000 meters, or a little more. Many roadside plants creep up even higher. Very few plains plants pass above 2,300 meters.

Of the plants on the foothills and in sub-alpine regions, many are well known farther east at ordinary altitudes, although not occurring in the plains region of Colorado. Mention may be made of *Dasiphora fruticosa*, *Pulsatilla hirsutissima*, *Arctostaphylos uva ursi*, *Chamanærion angustifolium*, *Populus tremuloides*, *Pyrola spp*. Throughout the foothills the dominant plants among trees are conifers; in fact the other trees are so few that they may almost be left out of account so far as the general appearance of the landscape is concerned. The quaking asps in some places, however, are in sufficient numbers to make an appreciable showing.

Perhaps the one feature of the vegetation to which special attention should be called is the natural massing of plants of a species in large areas. Instead of a few plants of one kind and a few of another there may be a hundred or a thousand individuals of a species crowded together. At flowering time these masses are most striking in appearance. Whole hillsides or great gullies will be blue with *Pentstemons* or yellow with *Arnicas*. Masses of *Arnica* plants in flower on the foothills can be seen for long distances as distinct yellow patches. These plants are not to be considered as exceptional. Many other species also occur in large masses. This is especially the case with early flowering species. The months of May and June make the growing season for most plants. In those months the colors of the hills and gulches change very quickly. The various species blossom one after another in quick succession. After the summer solstice the green hills and mesas change to brown, but in late summer they become green again when the large composites are well grown. When these composites are in flower there is a greenish yellow color everywhere, but in a short time this is brown once more.

It is a common idea among tourists and even residents that there are no bright autumnal colors in Colorado There is, however, no foundation for this belief. The poison ivy, the grape and the Virginia creeper are quite as brilliant in the Rocky Mountains as in any other region. *Edwinia* assumes a most beautiful coppery red color in autumn, and the hills and canon sides are everywhere aflame with sumacs and roses. It is true that in the cities one may miss the brilliant reds of the hard maple and black oaks, for these trees are seldom planted, but there are instead the yellow cottonwoods, locusts, soft maples, walnuts and elms. Another wrong idea which is quite prevalent is that the Rocky Mountain flowers are without much odor. Some flowers here, as elsewhere, are scentless, but there is no reason for thinking that all, or most all, are different from the plants of other regions in this respect. The more familiar one becomes with the plants of the Rocky Mountains, the more he becomes impressed with the fact that they are much like the plants of the eastern United States. The flora of the eastern slope of the great divide shows at every turn its close relationship to the flora of other parts of the Mississippi basin.

The Phylogeny of the Cotyledon.

The Phylogeny of the Cotyledon.

HAROLD L. LYON

A theory concerning the phylogenetic origin of any plant structure must necessarily be, in major part, but speculation, for in such discussion one can not determine all the factors which may have induced the mutations, nor keep in view all the transitional stages which led up to the ultimate organ. Any reasonable hypothesis well grounded on observed facts may be offered as a contribution to science, since it furnishes a basis for the correlation of facts. The results of investigations as they are recorded from time to time do not stand out as simple isolated facts, but through existing theories help to explain and interpret other phenomena.

An hypothesis concerning the phylogeny of any organ involves the phylogeny of the organisms possessing that organ, in this case the Angiosperms. That the Monocotyledons and Dicotyledons have a common ancestry there is no reason to doubt. One would hardly suppose that the similar complicated cytological phenomena of embryo-sac development and endosperm formation were simply parallelisms in two groups of different phylogenetic origin. The once credited theory however, that the Angiosperms were derived from Gymnosperm stock, receives little support in the light of modern research; the evidence now obtainable pointing rather to the separate genetic origin of these two groups from pteridophytic stock. Any discussion as to whether they represent diverging lines from an originally seed-bearing ancestor, or are two distinct groups in which the seed-habit has been separately evolved, must at present be purely speculative. It is quite improbable that modern Pteridophytes represent, in any considerable degree, the ancestral prototypes of the Angiosperms. Nevertheless, interpretations of angiospermic structures must be cast in terms of pteridophytic morphology.

The characters assumed by the cotyledons of many Angiosperms upon germination apparently place them in the category of leaves, in fact the resemblance is so marked that this interpretation has been generally accepted by botanists without serious question. Sachs writes: "We see that Cesalpino uses the same word 'folium' without distinction for calyx, corolla and ordinary leaves; just as he, and Malpighi a hundred years later, unhesitatingly regarded the cotyledons as metamorphosed leaves. In fact the envelopes of the flower and the cotyledons approach so nearly to the character of leaves that every unprejudiced eye must instinctively perceive the resemblance." This explanation no doubt first grew out of observation upon dicotyledonous seedlings having epigean cotyledons which took on the character of leaves. Comparative study of embryos showed that hypogean cotyledons were homologous structures, which failed to assume the photosynthetic function. The investigations of Gærtner, Poiteau and Mirbel, recorded now for almost a hundred years, established the fact that the cotyledon of the Monocots was an homologue of that of the Dicots. Poiteau originated and Mirbel supported the doctrine, which receives credence to-day, that the epiblast of certain grasses represents a second vestigial cotyledon, thus indicating a dicotyledonous origin for this family.

Nägeli, however, departed from the universal view when he said: "Der Embryo der Gefässkryptogamen und der Phanerogamen ist kein Caulom, sondern ein Thallom, wie das Moossporangium, aus dem er phylogenetisch hervorgegangen ist; die Samenlappen sind keine Phyllome, sondern Thallomlappen. An dem Embryo tritt als neue Bildung der Stengel auf." He implies that in its ontogeny the plant recapitulates its phylogeny, that as an embryo it is simply in an undifferentiated 'thallom' condition comparable to the moss sporophyte from which it was phylogenetically derived, and that the stem, phylogenetically of more recent origin, later arose as a new structure through the differentiation of the thallome. But

Nägeli's hypothesis effected no perceptible modification in the prevailing theory which is today generally accepted as portrayed in the following quotation from Gœbel's Organography. "I need only say here that the cotyledons, which so frequently differ in form from the foliage leaves, are merely arrested forms of these, the arrest being sometimes permanent, sometimes transient."

Many students of angiospermic embryology have recognized difficulties in this interpretation, but have accepted it for want of a better. It is based solely upon the resemblance which the cotyledons of certain seedlings bear to the foliage leaves, while their origin, structure and primary function would seem to disclaim such a relationship; for the cotyledons do not arise as exogenous lateral outgrowths upon the growing point of a stem, as do all later foliar structures, and even when epigean, as Gœbel notes, they usually differ in a marked degree from the ordinary foliage leaves. If similiar in outline, there is almost always a decided difference in venation. These variations have been explained as a retention of the form of ancestral leaves by the cotyledons. Were this true one should expect to find similar cotyledons throughout a family, or at least among the species of a genus.

The habitual production of three cotyledons of equal rank by *Nuytsia floribunda* would, according to the foliar theory, indicate that it represents a third class of Angiosperms (Tricotyledons) in which three leaves instead of two or one were originally arrested in the seed. But, as a matter of fact, numerous dicotyledons occasionally produce embryos with three and sometimes four perfect cotyledons, as for example *Acer*.

The production of an apparently dicotyledonous embryo through the bifurcation of the originally single cotyledon of *Nelumbo*, has suggested that this might have been the method of origin of the dicotyledonous habit. In *Nelumbo* the cotyledon is at first a crescent shaped mound of tissue running around the rear upper surface of the embryo. The plumule arises in the sinus between the points of the crescent. The pseudo-cotyledons later arise through localization of growth so that ultimately they occupy positions on either side of the plumule as in a truly dicotyledonous embryo. The cessation of growth in the median line, and its localization in the wings of the cotyledon, take place at an early stage in the embryogeny. The transition from this pseudo to the truly dicotyledonous habit would be brought about by the continued earlier cessation of growth along the median line, and finally its complete localization in the wings of the cotyledon, *i. e.*, on either side of the plumule. The monocotyledonous condition would then be considered the more primitive, and the question would now arise as to the ancestral origin of this structure in the Monocotyledons themselves.

The function of the cotyledon in the Monocots is pre-eminently that of a nursing organ to absorb the food-materials from the endosperm and turn them over to the use of the growing embryo, as illustrated in the germination of corn, cocoanut and others. Primarily it is an embryonic organ, and its phylogenetic origin should be looked for in simpler types of embryos.

In the embryogeny of certain Pteridophytes there occurs a simple protruding mass of tissue between the root and shoot fundaments the sole function of which is that of a nursing organ, a genuine haustorium, which absorbs nourishment from the gametophytic thallus for the sustenance of the young embryo. It is to the pteridophyte embryo in a simple way what the cotyledon is to the embryo of a Monocot, and is in fact to be considered as a more primitive type of cotyledon. This in brief is an outline of an hypothesis which seems tenable.

In its ontogeny a seed-plant experiences two distinct environments, the one characteristic of its intraseminal life, the other of its extraseminal. The intraseminal life, which begins immediately upon the formation of the oösperm, is passed within a definite limited space. During this period of its existence the plant lives wholly as a parasite, nourishing itself upon the food-materials stored in the adjacent tissues. It is a true parasitism fostered by the parent for the good of the species. It is not a condition originating in seed-plants, but traces back to the first simple Bryophyte which retained the oösperm within the female reproductive organ and nourished the young sporophyte from food-materials of its own accumulation. The extra-seminal life is the continuance of a habit which the sporophyte later developed of assuming an independent vegetative condition after the tissue of the gametophyte had been exhausted. The retention of the female gametophyte within the sporangium marks the origin of the seed-habit, but the parasitic habit of the sporophyte was already a condition of long standing. Is there any reason to suppose that this retention of the gametophyte has caused the embryo sporophyte to discard the ancestral nursing organ, the nursing-foot, and employ in its place foliage-leaves, structures characteristic of the free life of the sporophyte?

From this point of view a cotyledonary structure first makes its appearance in the Hepatics. The sporophyte of *Riccia* absorbs nourishment throughout its entire surface, but that of *Marchantia* responds to its parasitic condition by the sterilization and specialization of a portion of its tissue as an absorptive organ, commonly termed the nursing-foot. In Marchantia the nursing-foot consists entirely of tissue derived from the hypobasal cell of the segmenting oösperm, but in *Anthoceros* and the Jungermanniaceæ a portion, and in some forms the greater part, is contributed by the tissues derived from the epibasal cell. All the moss sporophytes possess a nursing-foot which is developed from the hypobasal cell with additions of epibasal tissue. Passing from the condition in *Marchantia* to that seen in the more highly differentiated sporophytes of the Bryophyta, there seems to be a gradual diminution in the relative size and importance of the hypobasal portion of the foot, the absorptive function being discharged almost wholly by the more bulky epibasal portion, as may be especially well seen in *Sphagnum*. In the Lycopodinæ the hypobasal portion has abandoned its primary absorptive function and accepted another connected with the change in oösperm orientation. The functional nursing-foot in the Lycopodinæ is developed entirely from tissues of epibasal origin. In the Filicinæ and Equisetinæ the foot is developed from a part or the whole of the hypobasal cell, without additions of epibasal tissue.

An explanation of this displacement of the foot primordium in these cryptogamic embryos is to be sought in the changing inter-relationship of the sporophyte and gametophyte, and the growing importance of the free life of the sporophyte. The ultimate independence of the latter was realized through the evolution of a new structure, the root. Whether the root primarily arose as a terminal or lateral structure, from tissue of epibasal or hypobasal origin, is a matter of speculation and of little importance to our present discussion. In either case as the sporophyte came to pass the greater part of its life as an independent organism, the axial relation of the stem and root would become of more importance to the plant than the axial relation of the stem and foot, and as the stem and root must both become free from the gametophyte, the foot would necessarily come to occupy a lateral position with respect to the vegetative axis of the plant. The embryos of the Bryophyta are bi-polar, the foot occupying a basal position, but with the advent of the root in the Pteridophyta their embryos become tri-polar. When a main vegetative axis is established, however, it is between the two members which will persist in the bi-polar vegetative body.

The establishment of this axial polarity at earlier or later periods in the embryogeny of different plants accounts for the apparent displacement of the primordia. The influence of their ultimate positions has been carried back so far in the embryogeny of the ferns, which very early become independent, that there has evidently been a displacement of the primordia within the oösperm itself, for the root primordium arises from a hypobasal octant diametrically opposite the stem primordium, and the foot arises as a lateral organ from two other hypobasal octants.

In the embryogeny of the sporophyte the Monocotyledons as a class show considerable diversity. The greater number of investigated types conform more or less closely to a definite scheme, of which the embryogeny of Alisma affords a good example. The oösperm first divides by a basal wall at right angles to the longer axis of the embryo-sac. The hypobasal cell (next the micropyle) becomes the suspensor cell, while the epibasal cell through further divisions produces the cotyledon, stem-apex and primary root. The first division in the epibasal cell is parallel to the basal wall. The embryo now consists of a row of three cells. From the apical cell the cotyledon is developed, from the central cell the stem and root primordia. Although the cotyledon arises as a terminal member in respect to the original axis of the embryo, it is a lateral member with respect to its position upon the vegetative axis which is later established.

Of the embryos of the Pteridophytes, that of *Selaginella* shows the nearest approch to those of the Monocotyledons. This does not necessarily indicate that it should be considered an ancestral type. Although originating laterally, the cotyledon of a *Sela-*

ginella embryo very early comes to occupy a terminal position opposite the suspensor. The stem apex originates terminally, but is forced into a lateral position by the growth of the cotyledon. The root originates in the tissue adjoining the suspensor opposite the stem. In the Monocots this displacement has become a constant character, the terminal position of the cotyledon being apparent from the earliest divisions of the embryonal cell.

The transition from the monocotyledonous embryo to the dicotyledonous embryo, as illustrated by *Nelumbo*, has already been indicated. It is the result of a division of the cotyledon primordium followed by a further displacement of the primordia.

The remarkable change in the embryonic conditions instituted by the seed-habit readily accounts for the rapid departure of the cotyledon in the Angiosperms from the ancestral pteridophytic type. The embryo of a typical Pteridophyte is attached to a fixed living organism, growing on or in the soil. All the nourishment absorbed by the cotyledon is passed on directly and is used by the continuously growing embryo. The seed-habit, on the other hand, divides the ontogeny into two distinct periods of growth with an intervening dormant period. The intra-seminal life is a prolonged embryonic period during which the plant depends entirely upon neighboring tissues for nourishment. In its own tissues or with it in the seed must be stored a food-supply which will enable it to establish itself in an independent condition on the resumption of growth. While an Angiosperm embryo is obtaining its independent condition the cotyledon is enclosed in a non-living movable seed-coat. The problem of food storage in the seed is met in the various well known ways by different Angiosperms. The primitive methods of storing it in the megaspore and gametophyte were no doubt first supplanted by the formation of the perisperm and endosperm, but a more advanced condition is arrived at in exalbuminous seeds where the food-materials are stored directly in the tissues of the young embryo rather than in an intermediate structure.

In the seed the cotyledon necessarily assumes new functions and a greater importance due to the extended embryonic period. Primarily a nursing-organ, it readily assumes the additional function of a storage-organ, accommodating itself to the available space within its investments. The multifarious cotyledons which result through a greater or less degree of response to the divers influences surrounding the intraseminal life need not be enumerated here.

The assumption of the vegetative habit by some cotyledons is a natural outcome of their becoming epigean upon the germination of the seed. For all portions of the seedling exposed to the light produce chlorophyll to provide for the immediate needs of the young plant. The cotyledons usually become epigean through the elongation of the hypocotyl, a structure appearing for the first time among the Angiosperms. Its development was made possible by the fact that the cotyledons need not remain in or at the surface of the soil during germination—a condition arising with the seed-habit. The hypocotyl is differentiated between the primary stem and root and is essentially different from either, as has been amply demonstrated by several investigators. That many epigean cotyledons should acquire the form of true foliage-leaves is not altogether remarkable, for they are functionally similar structures in the same environment.

With our present meager knowledge of the embryology of Gymnosperms, it is a difficult matter to explain the varied unique developments of their embryos. With the exception of *Gnetum* and *Welwitschia*, the embryogeny begins by repeated free nuclear divisions within the oösperm. In the conifers the number of nuclei resulting is limited to a few which pass to the base of the oösperm and by free-cell formation organize the proembryo. In the cycads and *Ginkgo* a large number of free nuclei are produced which in *Cycas* organize the huge bag-like proembryo, while in *Ginkgo* they enter into a compact tissue from which the embryonal stem and root primordia are later differentiated.

The so-called cotyledons of the Gymnosperms are, so far as definitely known, true leaves arising as exogenous outgrowths upon the growing point of the stem.

Gnetum and *Welwitschia* in their embryogeny show the least departure from the pteridophytic type. Free nuclear division does not take place, the oösperm giving rise directly to a suspensor on the end of which an embryo is produced. When germinating, as the root pushes out from the seed, there is developed at the base of the stem a lateral protuberance which remains in the seed and absorbs nourishment from the endosperm and passes it on to the rest of the embryo. The orientation of this feeder, as Bower terms it, is not constant in its relation to the other members of the embryo. It always occurs just above the transition plane between the stem and the root, but its position on the circumference of the embryo is determined by the direction of gravity. The seed of *Welwitschia* is more or less flattened, and no matter which side up it lies when germinating the feeder is developed on the concave surface of the embryo as the root grows out and down into the soil. It may then arise in either of two positions. The seed of *Gnetum* is polysymmetrical and the planes of symmetry of the embryo bear no definite relation to the direction of gravity during germination. The feeder always arises on the under side of the embryo and hence may be developed at any point on the circumference. Bower readily shows that this feeder is the homologue of the nursing-foot in the Pteridophytes. Clearly then it is a true cotyledon, and in its position and function during germination is remarkably similar to those of the Monocots.

The Gymnosperms are an ancient seed-bearing race, and the peculiar modifications in embryogeny are undoubtedly due to the long continued intraseminal parasitic habit of the embryo. These peculiarities may be looked upon as being induced by habitual parasitic nutrition, just as remarkable morphological changes of the extraseminal plant body have been wrought by parasitism in many Angiosperms (Orobanchaceæ, Rafflesiaceæ, etc.). The abundance of nourishment in the seed might be considered the cause which has led to embryonal propagation (polyembryony) in many species.

The embryos of *Gnetum*, *Welwitschia* and probably of *Ginkgo* and the Cycads produce true cotyledons which remain in the seed during germination. While the embryos of *Gnetum* and *Welwitschia* remain embedded in the tissue of the gametophyte, they apparently absorb nourishment more or less throughout their entire surfaces, the cotyledon remaining indistinguishable as a definite organ. As soon, however, as the stem and root begin to leave this tissue the growth of the cotyledon is rapid and it quickly assumes proportions commensurate with its functions. From this example afforded by the embryos of *Gnetum* and *Welwitschia*, we might conclude that the cotyledons of Conifer embryos are never called upon to function and hence never develop.

SUMMARY.

1. The typical embryos of the Pteridophyta and Angiosperms differentiate into three primary members—the cotyledon, stem and root.

2. Cotyledons are not arrested leaves but are primarily haustorial organs originating phylogenetically as the nursing-foot in the Bryophytes and persisting throughout the higher plants.

3. The monocotyledonous condition is the primitive one and prevails in the Bryophytes, Pteridophytes, Monocots and some Gymnosperms. The two (sometimes more) cotyledons of the Dicots are jointly the homologue of the single cotyledon of the Monocots.

4. The cotyledon always occurs at the base of the primary stem.

5. The hypocotyl is a structure peculiar to the Angiosperms, being differentiated between the primary stem and root.

6. The so-called cotyledons of the Pteridophytes and Gymnosperms, with the probable exception of *Ginkgo* and the Cycads, are true foliage-leaves.

NOTES.

1. The exact method of origin of the so-called cotyledons of *Ginkgo* and the Cycads is unknown, but their position at the base of the stem and their conduct during germination are strong evidence in favor of the view that they are homologues of the feeders of *Gnetum* and *Welwitschia*, and hence true cotyledons.

2. In *Gnetum* the suspensor sometimes branches, when an embryo is produced on the end of each branch.

3. The repeated displacement of the cotyledon to different points on the circumference of the embryo would seem to indicate that an area entirely

around the axis was potentially cotyledonary, a maximum development taking place at such a point as is in the most favorable position to function. Thus, it occurs next the suspensor in *Lycopodium* and opposite the suspensor in *Selaginella.* In *Gnetum* it develops at that point on the circumference which will be nearest the seed while the vegetative condition is being established. In the Monocots it extends nearly and sometimes quite around the axis, but usually experiences maximum development on one side. In the Dicots equal growth takes place at two points diametrically opposite each other.

If it should be maintained that the primitive root originated as a terminal member, the originally basal cotyledon would then have become a ring of tissue around the embryo at the junction of the stem and root. Conditions later arising made it necessary for the stem and root to come out on the same surface of the gametophyte, when only one side of this cotyledonary ring could remain embedded in the prothallium. The different positional relations which the various embryos bear to the gametophytes would bring different portions of the cotyledonary ring into favorable positions to function. In the seed the embryos of Angiosperms are brought under conditions which seem to stimulate development throughout almost the entire cotyledonary ring.

Botanizing in Jamaica

Botanizing in Jamaica

ELOISE BUTLER

A strong desire to study tropical vegetation resulted in my embarking with my sister from Boston on a Monday evening in June, 1891, on a banana steamer accommodating a few passengers bound for Port Antonio, Jamaica. After a day and night of fog we reached the Gulf Stream, and soon sailed apparently upon a veritable "sea of glass." The smooth, glassy waves were occasionally spread with carpets and streamers of golden brown seaweed, *Sargassum bacciferum*, and frequently schools of flying-fish with silvery wings rose a foot or more from the water and gracefully floated in the air some distance before dropping again into the sea. As we had read that these fish did not use their wing-like fins to direct their flight, but simply gave a flying leap into the air, we were interested to see that often one turned in its course. This action seemed to prove that the fish did really fly somewhat as a bird does. We also saw for the first time the Portugese-men-of-war gliding rapidly over our "sea of glass" like large soap bubbles driven by gentle winds, and reflecting rainbow hues in the sunlight. We watched the changing clouds, occasionally a dark curtain falling between sky and water somewhere off in the distance, and we were informed "there is a shower over there." We gazed into the wonderful deep blue sea of the tropics, a blue so intense as to seem almost tangible. We played whist, or read seated upon the hurricane deck. We fed the Mother Carey chickens with crumbs from the table, and pressed specimens of *Sargassum* which the sailors kindly fished up for us by means of long boat hooks. The specimens varied as regards the length and width of the fronds, and they have been classified as *Sargassum bacciferum* and *S. bacciferum* forma *angustum*.

On Saturday we saw the first land since leaving Boston. San Salvador came into view as a mere speck on the horizon. We watched this speck most intently until we were enabled to make out a lighthouse on a long, low strip of land far away to our right. Then we again watched it recede from view, recalling all we could remember and imagine of Columbus' wonderful experiences on that first momentous voyage to the new world when this island came into view to cheer his despairing men and to reward his unparalleled faith and courage. The excitement of seeing San Salvador had barely subsided when we were informed that we were about to cross the Tropic of Cancer. It was intensely interesting to realize the moment we were crossing that imaginary line, and we marveled that man had been enabled to formulate accurate rules by which sailors could locate their position at any time upon the trackless deep. After a most gorgeous sunset, with such forms of clouds and such brilliant colors as can never be witnessed elsewhere than far out at sea, darkness following soon without the lingering twilight of the North, we were gazing for the first time upon the Southern Cross Poets and writers of romance had so inflamed our imaginations regarding this constellation that,

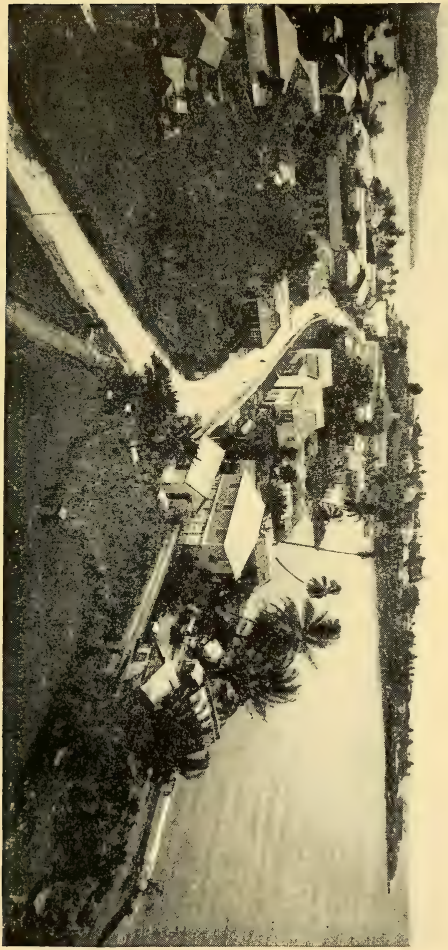


PLATE X. — Port Antonio, Jamaica.

we must confess, it did not quite meet our expectations. But we may have seen it at a disadvantage, as it was very near the horizon.

Sunday morning the mountains of Cuba appeared like clouds over the sea, but soon we were sailing close by the eastern shore, and could distinguish the scanty vegetation upon the sides of the mountains, most curiously terraced and grooved by deep ravines.

Monday morning we awoke to find ourselves gliding into one of the most beautiful small harbors in the world, and our eyes were feasting upon tropical scenery. And the half of its marvellous beauty and fascinating interest had never been told.

Our second voyage was in 1894, at about the same season of the year. But, though now the Fruit Company's steamers were much larger and swifter, and the accommodations for passengers were not so limited, the time spent at sea was much less enjoyable, as, owing to continuous rainy weather, we never saw the sun from the beginning to the end of the voyage. Moreover, our state-room sprang a leak, and we were drenched in our berths; yet our ardor for studying plant life in Jamaica was not in the least dampened, for we had no sooner returned from this trip than we began to plan for a third; but, there were so many difficulties to surmount, the summer of 1900 arrived before we were enabled to spend another four weeks on the island. This last sea voyage in a steamer, yet again so much improved as to seem impossible for the Fruit Company to do any more for the comfort of its passengers, was varied by days of rain and of sunshine, the latter predominating.

The fruit steamers always enter at Port Antonio, then sail along the coast west to Lucea, or east to Morant Bay, sometimes rounding the eastern point and continuing along the southern shore to Kingston, stopping at numerous little harbors between these ports to take on bananas, and usually returning to Port Antonio to clear. It was our custom to remain aboard the steamer while it was sailing about the coast; and, during the loading of bananas, we went ashore to search the beaches for seaweeds, or to stroll through the streets of the little villages to note the different varieties of fruits and flowers by the wayside and in the gardens of the negro cabins. In this way we had opportunities to make collections at many places besides those at which we made lengthened stops for that purpose.

There being no wharfs excepting at a few of the larger ports, in order to go ashore at some places, we were lowered from the steamer's side into a row boat, manned by two or three negroes and used for bringing bananas to the vessel, the waves tossing the boat so violently that we had to be skilfully caught by the boatmen as though we were bunches of bananas. After rowing as near the shore as possible, we were again taken in the negroes' arms and carried through the shallow water to dry land. These dark stevedores were most picturesque creatures; they were invariably clothed in rags, tied and fastened on in most ingenious ways. Patches of all hues and shapes were attached here and there among the tatters. Their head-gear also was particularly interesting. Gaudy bandanas, straw and felt hats in every stage of dilapidation, brimless crowns and crownless brims, caps of various materials, one even of fur, were among the head coverings we noted. The women often wore flower and ribbon-trimmed hats over turbans.

Whenever the conditions were not favorable for us to go ashore we never ceased to be amused by watching the loading from the vessel's deck. The streets and footpaths leading from the surrounding hills and mountains to the little coast village near which our vessel was anchored were sometimes thronged with carts of fruit drawn by single mules and pairs of mules or oxen, or donkeys with deep panniers hanging from each side, a negro woman or child perched on top guiding the animal with a single rope fastened about its nose, and pedestrians, men and women, also loaded with bananas, the men carrying bunches in their hands and the women invariably carrying them on their heads. The women carried all their burdens on their heads, from a spool of thread, or vial of medicine, to a full calabash of water, or heavily loaded basket. Row after row of these grotesquely garbed negro men, women and children, all chattering, laughing or scolding, making a perfect babel, marched down into the water, often waist deep, to deposit their bunches of bananas in the waiting boats, which, as soon as filled, were rowed off to the steamer, where the fruit was passed up to other colored men standing at openings in the hold of the vessel. Every bunch as it was handed up was counted by a man whose especial duty it was to keep the tally, and his

"Banana one,
Banana two,
Call this one three,
Banana four,
Call this one tally-o-o-o!"

rang out in his musical voice as a cheering song.

The limits of this sketch will not permit me to more than allude to a few of our many interesting experiences. There was no hotel at Port Antonio in 1891, and the only available place for the accommodation of strangers was at a lodging-house, standing on a steep bluff overlooking the harbor, conducted by a handsome, dark creole. Colored servants, big and little, were numerous. Everything was done for our comfort and happiness in the peculiar way the mistress and servants had of doing things. Fresh from New England homes, we were much interested in noting the differences between creole and Yankee housekeeping.

We arose at daybreak and went to the bath-house, which was provided with a large stone swimming tank, supplied with water from a mountain stream. The cold morning bath is absolutely necessary in the tropics to keep the system in tone. After being served with coffee, we started on our collecting tour, remaining out until about ten, when we returned to take another bath and attire ourselves in fresh garments for breakfast. This second bath and entire change of clothing was always necessary after collecting, whether we went wading in the ocean, or walking in the woods, for we were always wet and muddy whichever course we took.

While exercising in the tropics one perspires very profusely. Then showers

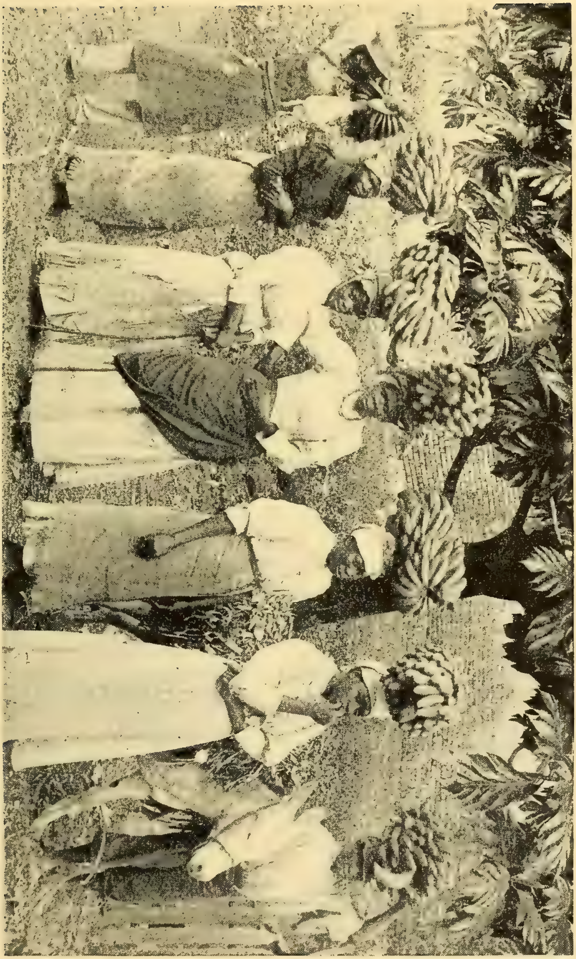


PLATE XI. — Banana Carriers.

are so frequent that the soil and rank vegetation are reeking with moisture. We always carried an umbrella to protect us from the sun or from the showers. Though we could not long exercise in the sun's direct rays, beneath the shelter of our umbrellas the heat was more easily endured than when botanizing many summer days at the North. Jamaica is in the line of the cool trade winds, so when in the shade, one is very comfortable. Moreover, the temperature is never so high in Jamaica as it is in our hottest summer weather, the thermometer ranging from the sixties (Fahrenheit) to about ninety as the highest.

After breakfast we usually worked upon our morning collections until time to dress for five o'clock dinner, another light lunch of cake and fruit being brought to our room between one and two o'clock. Dinner was much like the breakfast, with the addition of a usually delicious, strangely concocted soup and a dessert. About eight in the evening we were served cake and tea in our rooms, or in the drawing room, wherever we might be. The general cooking at this house was done by two or three old witch-like negresses over an open fire in a dark cavern in a precipice forming the boundary wall to one side of our yard.

Our room was small and crowded with "missus' things," which were not removed for our accommodation. A large bed with one starched sheet and an indescribably hard mattress, a big wardrobe, a bureau, a washstand and our two large trunks so filled the room that one could scarcely stand between the bed and surrounding furniture. All the drawers and various boxes under the bed also contained "'missus' things," and the big cockroaches rattled around in them all night, to the disturbance of our slumbers. We had to use the bed by day for a work-table, having also a little folding table that we carried with us, which we could tightly squeeze between bed and bureau, and upon which we washed out our seaweeds for mounting. It was very ludicrous, when using this folding table, to have to scramble out over the bed covered with specimens to get to the door, or to close our jalousied windows when a heavy shower came beating in.

Little maids came in every morning while we were off collecting and scrubbed the floor, using a dark colored tea made of mangrove bark, the scrubbing brush being a cross section of a cocoanut gathered before ripening. We also saw floors polished with sour oranges cut in halves, and with a tea made of *Mormordica Charantia L.*, a pretty little vine bearing a yellow flower, which the natives called "Cerasee Tea." The floors everywhere received more attention than any other part of the dwellings. To our knowledge, cobwebs and dust were never removed from their usual lodging places on windows, mopboards, etc.

While upon household matters, I will briefly relate our boarding experiences elsewhere, when revisiting the Island. In 1894 we disembarked at Annotta Bay, a little, low-lying village between the mouths of two sluggish rivers, and said to be the most unhealthy place in Jamaica. We passed the first night at "The Army and Navy," an imposing name for a primitive little hostelry. We were given a large room having two single beds, each provided with the one stiff sheet, but we carried sheets with us after our first experience. At breakfast we were served first a saucer of oatmeal and milk. This looked homelike, but one taste was sufficient, for it was simply saturated with smoke. Bacon and eggs came next with the same result, and so on to the fruit. This we could eat, but we were surprised to see the waitress take our plates, throw their contents out of the open window and return them for us to eat our fruit from. All refuse is disposed of in this simple manner. Turkey buzzards, called "Jim Crow" birds, sit perched on the roofs, or near-by tree tops, on the alert to fly down and gobble up every scrap of waste food thrown out. These birds are protected by government for scavengers.

On rising from the table, we passed to the window and gazed down upon an enclosed yard in which was a little cook-room made of rough boards, roofed over, and on the four sides beneath the roof was a broad open space, out of which poured dense clouds of smoke. In the center of this room stood an iron cook stove, the only one we saw on the island, and the stove was provided with the usual pipe, which neither entered a chimney nor protruded from any aperture, but simply left off about a yard above the stove. It was certainly no less than a miracle that any human being could stand and cook in such an atmosphere; but the flavor of the food was no longer a mystery.

One of the officers of the Fruit Company stationed at this port called on us early in the day; and, as he was to be away with his family, he asked us to accept the use of his cottage, housekeeper and retinue of servants while we were to stay in Annotta Bay. We accepted his exceedingly generous offer and a week of great enjoyment followed.

Our time here, and elsewhere, was spent much as at Port Antonio; but, instead of being cramped in one little room, the whole house was ours; the housekeeper and servants, living in little cabins at one side of the large back yard, coming into our cottage only to serve our meals and to tidy the rooms. The cottage stood on the pebbly sea-shore, thus being very convenient for our seaweeding. Our housekeeper, a dark creole, served us the most delicious meals we had yet eaten in Jamaica. But, had we given the preparation of the food much thought, our stomachs would have rebelled. From our dining-room we could look out upon the large yard enclosed by a line of tall cocoanut palms, and, if our meal was in preparation, see several negroes, big and little, stooping over little wood fires between three bricks arranged in a triangle. In basins on these fires were steaming the various concoctions later appearing on our table in regular courses as fragrant soups, made dishes, strange native vegetables, fish, meat, desserts, etc. If the time of looking out happened after a meal, we would see the servants stooping over basins of cold water, washing the dishes, which were never wiped, but laid on the ground to dry, knives, forks, spoons, cups, saucers, plates,—everything. We would also see in that yard, frolicking in and out and over the drying dishes, numbers of little half-naked pickaninnies, a goat and two kids, dog and

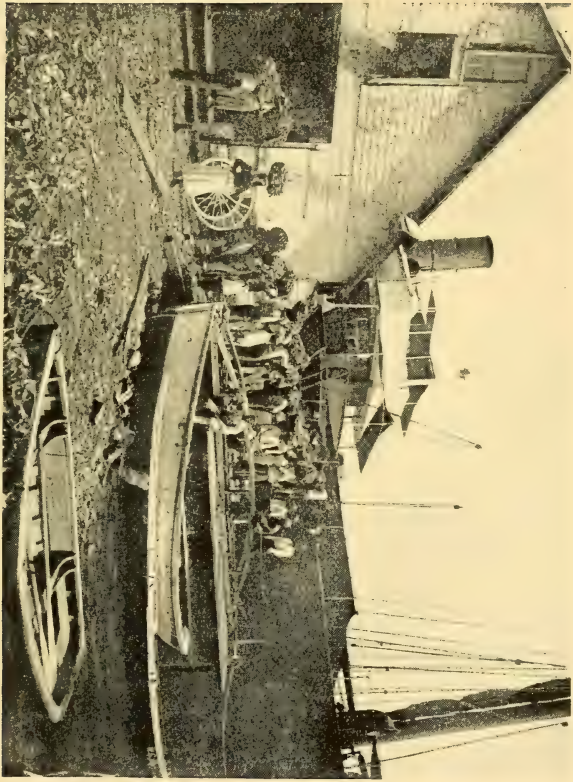


PLATE XII. — Loading Bananas.

five pups, and a flock of hens and chickens.

One day while here we drove many miles into the interior along the bewitchingly zigzag course of the wag water, to Castleton Gardens, the Arnold Arboretum of the tropics. Here we saw noble specimens of every species of palm on the globe, and many marvellous growing, blooming things that still haunt our memories. The bamboos everywhere charmed us, standing in clumps, gracefully bending like groups of Prince of Wales feathers. Another interesting tree was the banyan, introduced from India. The seed of the banyan, when lodged on another tree, takes root, grows rapidly and strangles its host. Branches grow down to the ground and also take root, a single tree thus forming a miniature forest.

After leaving Annotta Bay we

boarded two weeks at Morant Bay, in a delightful old Spanish mansion, an ideal tropical home on a steep hill with higher hills rising to the right towards the distant Blue Mountains towering among the clouds. In front and to our left, we overlooked banana and cocoanut plantations intersected by winding rivers emptying into the bay, which bounded our horizon at a distance of three or more miles. We were accorded the use of the "trap" and a driver to take us to the shore when we wished to seaweed; but the water was always so tempestuous in this bay that our algæ collections were not so abundant here as elsewhere. We took long drives to the mountains for ferns, once going to Atalle Gap in the Blue Mountains, a place famous for its coffee plantation. The Blue Mountain coffee is considered by epicures the best in the world, and the whole supply is shipped to London. This drive was one of the red letter days of our experience. We gathered most lovely ferns, gold and silver, and others remarkably rare and beautiful, and saw many wonders in scenery and plant life.

Another remarkable drive was to Bath, where is the famous hot sulphur spring boiling out of the mountain, side by side with a stream of cold water. Both the hot and the cold water are conveyed by pipes into a near-by building provided with stone tanks for bathing. Here sufferers from rheumatism and all cutaneous diseases are speedily cured by the hot baths. During our last trip we boarded a week at the village and took the baths, to our great delight. The hot sulphur water soothed tired nerves and muscles, and cured an eruption on face and hands caused either by a vegetable poison, or by getting over-heated.

In the neighborhood of the hot spring flourished a great variety of rare ferns. The scenery all about was exceedingly lovely, diversified, as everywhere in Jamaica, by rivers gliding rapidly over rocky beds, and cutting their way to the sea through mountains, thus forming many narrow valleys, which are often constricted to deep gorges with perpendicular walls. These walls are always draped with tangled vines, drooping ferns and orchid-covered trees wherever a root can take foothold. Soil is not necessary on this wonderful island for the growth of vegetation. The rocks, brick and stone walls, the trunks of trees, the roofs and very doorsteps of dwellings, have growing upon them mosses, ferns, orchids and very many other forms of plant life.

At Bath we had a charming temporary home at the lodgings of Mrs. Duffy, who is widely known and appreciated by all travelers in Jamaica.

Perhaps the neat, home-like attractions of Mrs. Duffy's lodgings would not have impressed us so forcibly if we had not come to them from a week at Manchioneal, where our accommodations at the only house open to strangers were intolerable. The lodgings (a name applied to the small hostelries throughout the island, there being no hotels, excepting at a few of the larger settlements) were admirably situated for our work, close to the shore at the head of the little harbor. Our seaweeding was so successful here that we were willing to endure even greater hardships. The mistress of the house, when not lying in a drunken sleep, maundered aimlessly about the rooms, carrying on a monologue in a most peculiar, high-pitched, whining tone. The food was scanty, unpalatable and poorly served.

We had the entire first floor to ourselves, the family occupying the basement, the fumes of the landlady's rum often coming up through our floor. My bed was far the worst I had yet encountered. Our sheets and pillow-cases we saw washed, starched and ironed after our arrival, though we had telephoned for our rooms several days before. Two immensely heavy mattresses filled with something hard and lumpy were piled on a bedstead without springs. These mattresses were so much thicker at one side than at the other that to keep on the bed I must lie crossways, my head on the sill of a little jalousied window, against which the bed stood, and my feet hanging over the front edge. Perhaps I might have enhanced my comfort by reversing the mattresses, but I feared to touch them, as they were unclean and the probable abode of centipedes and scorpions. With a proper mistress this might have been an ideal resort, as the house was pleasant, the surroundings charming and the air cool, the prevailing winds coming from off the bay.

When ready to leave Manchioneal we started out to see if we could find a banana cart to take us to Bath, and succeeded in getting the promise of a cart and driver to be at our lodgings at precisely half-past eight in the morning. Strange that, with the experience we had had in waiting for the movements of the natives in all parts of the island, we should get impatient as the minutes passed, then hours, until it was eleven o'clock, and no cart. I would wait no longer, but hastened off to learn why our equipage did not appear. I found the cart broken, and no attempt made to repair it, or to inform us of the mishap. I indignantly turned away and went in search of another cart, and was so far successful that I was promised one as soon as a man could go to the pasture and drive up the mules. Again I returned to the lodgings to sit and wait. In the vicinity of two o'clock the cart arrived. It was a two-wheeled affair, much like our ordinary tip-cart, drawn by a mule harnessed with ropes into the thills, and a little donkey tied on the left front corner to assist. The cart was too narrow to hold our one trunk crossways, so it was pushed in at one side of the

PLATE XIII. — Palm-thatched Bamboo Cabin.

back, the hand baggage occupying the space at the side of the trunk. Two small chairs were put in front for us to sit on. But there was not room enough for us to sit side by side; so one was bolstered against the driver and the other against the trunk with her feet beneath the other's chair. We presented such a ludicrous spectacle that we longed for some one with a camera to take our picture to send the friends at home. We laughed until we ached, with the tears streaming down our cheeks, and held on with both hands to keep from being jolted out. As the mule and donkey trotted and cantered up hill and down, our cart rattled and joggled so that we could scarcely hear each other's voices. No wonder that when we arrived at Mrs. Duffy's after being "drawn in a cart" three hours we were charmed with our new home.

Again we took a cart back to Manchioneal to connect with the mail coach for Port Antonio, driving part of the way along the coast and stopping at every available place to seaweed. We found the coach was not due until three o'clock in the morning, and after much demurring decided to go to bed to get some sleep. It happened that I had just dropped my watch and broken the main spring. No one in the neighborhood owned a timepiece. We asked the landlady how we should know when it was time to be ready for the coach. She replied "O, you will know all right. At eleven the roosters will crow a little, and again at twelve; at about half-past two they will crow some more and at dawn they will have the big crow—the whole lot crowing all together." Well, we must lie awake to listen for the cock crowing. It was not difficult to lie awake, for, after a week's comfort at Mrs. Duffy's, my sister could not drop to sleep on her Manchioneal bed; so after a brief hour of endurance she exclaimed, "Come, the rooster has crowed. It is eleven, and I am going to dress and sit up the rest of the night to watch for the coach." So we both dressed, got our luggage ready and sat by the open door to keep our vigil. Though common sense, taking the place of a timepiece, told us that it was not three o'clock, the waves beating on the rocky shore every few moments sounded like the coach tearing along over the street, and we would snatch up our hand bags, a plant press filled with specimens, a large basket of unmounted seaweeds and our umbrellas and rush down the steps onto the street to hear nothing in either direction but the beating waves, the croaking of lizards and the many insect voices of a tropical night. Then we would return with our bundles to our chairs to repeat this performance many, many times before the coach actually appeared.

We had a remarkable ride with our monkey, jumping-jack driver, in the early dawn, through a picturesque region, much of the way skirting the seashore. At first we were rather terrified at the reckless driving up and down steep hills, through dark woods and across rivers without bridges, the water often rising to the body of the coach. The driver continuously lashed the mules, first on the right, then on the left, the whip lash circling rapidly to and fro, the performance being occasionally diversified by his dashing down beneath the fender, the mules still on the jumping canter, to catch and refasten an unhooked trace, but always coming up all right on his seat again, though we feared every disappearance over the fender would be his last. As we approached a village, our driver, without seeming to cease for a moment his antics with the mules, would whisk out a horn and blow an ear-splitting blast which reverberated through the surrounding woods and hills, with the result that when we tore up to the little wayside cabin labelled postoffice the mail was always ready.

At Port Antonio there is now one of the finest hotels in the world, at least the most enjoyable at which we ever tarried, built and managed by the Fruit Company. Here we lived in luxury until we were ready to embark for home.

On our third trip to Jamaica we left the steamer at Montego Bay, an interesting old town with many of the buildings with massive stone and brick walls dating back to the Spanish possession, and fewer of the usual little board and bamboo-woven cabins.

Our lodgings here were most beautifully situated on a high bluff overlooking the town with its background of wooded hills, and the little semicircular bay with its circling arms of land buried in luxuriant tropical foliage. From the sea our Roman villa-like lodgings loomed up very imposing, but, truly, distance lent enchantment. For, though the house was large, the rooms airy and pleasant and the situation most desirable, shiftless housekeeping and monotonous fare spoiled much of the charm.

From Montego Bay we took the steam cars across the western end of the island to Kingston, stopping off for a day or two at Mandeville, a hill resort with an ideal climate and reminding one of a village in rural England. From Kingston we returned by the new railway across the eastern end of the island to Port Antonio, stopping on the way at Bog Walk, far famed for its rare ferns.

Columbus in describing Jamaica to Queen Elizabeth is said to have crushed a piece of paper tightly in the palm of his hand, and on releasing it exclaimed: "There is Jamaica!" Certainly, a true description of the island, which is entirely made up of mountain chains and peaks with intervening narrow, steep valleys. The coast is scalloped all about with little bays with usually bold shores. Annotta Bay is the only village I recall having any extent of level land.

As there is no perceptible tide at

Jamaica, our seaweeding was conducted rather differently than at the North. The seaweeds found upon the beaches were dashed up by unusually high waves after a storm; therefore collections made from the wrack were apt to be fragmentary. At Port Antonio, from the shore at one side of the bay, extended a large coral reef over which the water was shallow. Here, wearing our bathing suits, we could wade out and gather quantities of "Mermaid's shaving-brushes" (*Penicillus capitatus Lamarck*), *Caulerpa*, *Udotea*, *Halimeda*, *Corallina*, etc., rooted in the sand after the manner of terrestrial plants, and *Galaxaura*, *Dictyosphæria*, *Cymopolia* and various others on the rocks. At other ports such seaweeds as *Dictyota*, *Gelidium*, *Turbinaria*, *Sargassum*, *Padina*, *Amansia*, *Laurencia*, etc., grew on rocks off bold shores, down which we could not clamber; other species in muddy eel-grass flats far out from land, so that our sea-weeding had to be done from boats. Two or three negro boatmen rowing us wherever we desired to go, we jumped overboard (wearing bathing dresses and long-legged rubber boots), and fished about for the weeds. Where the algæ grew on rocks the water was usually very rough and we were often in danger of being washed off our feet; but we would cling to each other, one steadying the other while she dived for a desirable specimen. In this way at Annotta Bay we gathered quantities of "fairy umbrellas" (*Acetabularia crenulata* Lamour) and "tiny cat-tails" *Dasycladus clavæformis* [Roth] *Ag*) growing together on small stones and completely covering them, in water over our heads. The boatmen kept as near as possible to render assistance if we should meet with disaster.

The water was so muddy over the eel-grass flats that we had to dredge for our specimens with our fingers down among the roots. Of course we feared various stinging things, the water being plentifully supplied with them, but we never received any injury worth considering. One day, when dredging off Montego Bay, we were continually stepping on something that felt through our rubber boots like drowned kittens. At last we had the temerity to reach down and bring up one of the objects, and to our great joy and surprise it proved to be an unfamiliar seaweed (*Avrainvillea longicaulis* [Kutz.] Murr., and Bood). The plant was a most disgusting fleshy, hairy, dark brown thing, each specimen harboring colonies of small sea animals, causing us much trouble to cleanse the plant for preservation.

At Manchioneal we made a "great find," among other valuable collections. One day we brought our boat up among some big boulders close in-shore, beneath the bank of the village street. We clambered out to reach the sides of the boulders and were rewarded by finding large patches of a gloriously beautiful weed of most vigorous growth, and its color varying shades of purple. We instinctively felt that it was new to science, and we were eager to place it in the hands of the authorities on algæ. The plant proved to be *Gracilaria domingensis* Sond, which had been noted but once before, in 1869.

But this is not our only experience of this kind. On our first trip to Jamaica, on our sail up the coast before leaving the stream, we picked up, while ashore a few moments at Hope Bay, a bit of seaweed like a piece of stiff, greenish-gray fringe. This puzzled the algologists for a long time. They decided it was new to science and were considering what to christen it, when Mr. Collins, in an old French work, stumbled upon a discription of our *Liagora* (*decussata*), long since dropped out of the books as a freak of the imagination of the author Montagne, no specimen of such a *Liagora* ever having been seen by living scientists. We had the romantic honor of rediscovering a plant and vindicating the veracity of the old, long dead naturalist. This seemed much more interesting than discovering the the plant for the first time. But this honor, too, was in reserve; for, on our last trip, we found several new species, also a plant in fruit, never before found in that condition, and a species never before found outside the Red Sea, also several Australian species.

Unlike the huge algæ of the north-west Pacific, the seaweeds of Jamaica rarely attain a meter in length, *Liagora decussata* Mont, *Sargassum* and *Turbinaria* being the largest species. Neither do brilliantly colored specimens abound. The deficiency in size and bright coloring is counterbalanced by the odd, beautiful and fantastic shapes, as exemplified in the genera *Penicillus*, *Caulerpa*, *Udotea*, *Padina*, *Anadyomene*, *Chamædoris*, *Acetabularia*. The pròportion of lime-encrusted forms is large, as species of *Liagora*, *Halimeda*, *Galaxaura*, *Corallina*.

The fresh-water algæ, as far as I have observed, are not as abundant as in the North, or widely different from northern species.

All other vegetation is extremely varied. The forests are not made up of many trees of one sort, but at every turn different species are encountered.

Many of the marine algæ are local in distribution. For instance, on our second voyage we made an especial trip to Hope Bay to collect specimens of our *Liagora decussata.* We found it in windrows and filled our collecting bag, then inverted our open umbrellas and filled them, and, that not satisfying us, we gathered up our dress-skirts and filled them, going off the beach to the waiting carriage staggering under our loads. This we found at no other place, although diligently searched for.

Jamaica is truly the naturalists' paradise. It is a paradise for the entomologist as well as for the botanist. Insects abound. A kind of ant met us in swarms everywhere. Big, shiny, light brown cockroaches dropped eggs like black beans with a comb-toothed edge about our rooms. Ticks, jiggers and another infinitesimal little creature tormented us somewhat, but we had soothing remedies to allay the discomfort caused by their bites. Lizards darted about our rooms and everywhere through the shrubbery. But, best of all, there is no serpent in our Paradise. There never were any harmful snakes in Jamaica, and the few harmless ones have been exterminated by the mongoose, imported from East India to destroy the rats in the cane-fields. Centipedes and scorpions are said to be present, but, though we searched for them beneath rocks and fallen decayed tree trunks, we never saw any except those preserved in alcohol. We were assured that we could penetrate to all parts of the island and never meet with any harm from man or beast.

Algae Collecting in the Hawaiian Islands

Algae Collecting in the Hawaiian Islands

JOSEPHINE E. TILDEN

After spending several summers in work on the coasts of Washington and Vancouver Island, in which region the algal flora is, for the most part, arctic in character, it seemed that a study of tropical marine and fresh water vegetation would be beneficial. Previously no special collecting of this sort had been done in Hawaii, so that the discovery of interesting, rare and new forms might be expected. Accordingly, a trip to this group of islands was planned.

The party, consisting of my mother, myself and Miss Caroline M. Crosby, left Minneapolis on April 30, 1900, arriving four days later at Vancouver, British Columbia, where we went aboard the steamer "Miowera" in blissful anticipation of our first voyage on the Pacific ocean. In reality, so far as we know, nothing of interest occurred during the following nine days. There were fierce bleak winds and threatening skies and wild, swelling seas, under the influence of which was lost all desire to study algæ, tropical or otherwise.

At the end of eight disagreeable days came one pleasant one. The sun shone and the air was deliciously balmy. As our steamer was bound for Australia, preparations were being made for three weeks of hot weather. Saloons and state rooms were reappareled with fresh white draperies, and the sailors exchanged their dark blue uniforms for white duck. Strange looking sailing vessels and other craft were around us. Flying fish were abundant. Above all, land was in sight. Soon a hazy outline of mountains was made out. Diamond Head was distinguished; red hillsides and green valleys slowly became visible, and at last the fringe of coconuts on Waikiki beach. It was easy now to understand the nautical term "hug the shore," for we were all ready to embrace any form of soil that would allow a firm foothold. As we swung in towards the dock at Honolulu, we were not disappointed in seeing the naked Hawaiian boys swim out to the steamer ready to dive for pennies which the passengers threw over to them.

We of course looked for algæ around the wharf, but in vain. The only sign of vegetation of any kind were the wreaths of flowers (*leis*) which the brown natives wore on their hats, around their necks, or carried in their hands.

Probably no visitor was ever disappointed in Honolulu. Passing through the streets, perhaps the thing that impressed us most strongly was the number of ideally beautiful homes. The houses are not remarkable in themselves, but each is set in the midst of a grove of graceful trees, shrubs and foliage plants. A hedge of *Hibiscus*, with its mass of scarlet, an arbor covered with the trailing vines and purple blossoms of the *Bougainvillea*, or a veranda or *lanai* festooned with the green and white of the *Stephanotis*, gave the color and variety needed to offset the predominating foliage green ; for flower beds are rare in Honolulu. Glimpses of hammocks and tennis grounds made one feel that perhaps it was not worth while to spend quite so much time in labor. It was with regret that we turned our steps away from the city, for it was necessary to find a suitable collecting spot and begin work at once.

Having made a round trip journey over the Oahu Railroad and Land Co. line, the only railroad on the island of Oahu, we decided to locate our camp at the plantation of Waianae, thirty-three miles west of Honolulu. The third day found us comfortably established in pleasant rooms. A large unused, well-lighted back room in the railway station building was given us for a laboratory. We made tables extending around three sides of the room out of trunks and packing boxes. In front of one window the microscope was set up for Miss Crosby, and at the other were my quarters, where I could attend to my mounting and pressing. Certainly no more could be asked. It all seemed like a fairy tale. Our surroundings were perfect. Our new friends overwhelmed us with kindnesses. If only the algæ were forthcoming!

There was low tide early the next morning, and down to the beach we hurried. With a feeling of despair we scanned the rocks, for disappointment stared us in the face. To one accustomed to the mammoth seaweeds of the Straits of Fuca, which aggressively compel attention, the Waianae beach seemed absolutely barren. But, finally, a little, odd-appearing plant was discovered, and then a second, and down under a ledge of rock a bed of queer red bags, and, in a word, it was six weeks before we were able to stop collecting algæ on the shores of Waianae.

There was found to be very little difference between low and high tide,

PLATE XIV. — Hawaiian Fan-palm with Bread-fruit in Background.

about three feet in reality, but the low tides were generally accompanied by high waves, so that it was always difficult to collect.

We used to rise at five, awakened by the horribly discordant lay of a clock with a Chinese alarm. After a breakfast of rice, sweet potatoes, stewed mangoes or fresh coconut, we hastened to the laboratory for our collecting aprons, pails and knives, and then were off for a two or three mile trip up or down the beach. Among the more conspicuous and common forms growing on the rocks here were the following: *Microdictyon umbilicatum*, with its curious net-like frond; the somewhat remarkable *Dictyosphæria favulosa; Halimeda tuna; Caulerpa taxifolia*, looking like a *Lycopodium* prostrate and half buried in the sand; two interesting varieties of *Cladophora* which have recently been pronounced new by Herr Brand—*Cladophora composita contracta* Brand and *Cladophora montagnei waianeana* Brand. Incoming waves generally brought a supply of *Codium adhærens* and *Codium tomentosum*, both of which are known as *aalaula* by the Hawaiians and used, uncooked, as food. In certain places were beds of the well-known *Padina pavonia. Hydroclathrus cancellatus* was a stiff, brown, perforated cushion. *Turbinaria ornata*, one of the most highly specialized types of the Fucaceæ, bearing its fruits on short, stiff, umbrella-like branches, grew always just where the waves were so strong and high that no one could possibly reach it. Two species of *Sargassum*, growing together, extended over a wide area and were not seen again on the islands. The fronds of these, ground up into bits and mixed with raw fish torn into small shreds, formed a sort of salad very highly prized by the natives. Boiled with squid, they were also regarded as a great delicacy. The native name was *limu kala*. The red algæ were most common. *Asparagopsis sanfordiana* had the appearance of a little pink or flesh-colored pine tree, and, though most frail to the touch, it stood with ease the onslaught of the waves. *Wrangelia penicillata*, a pretty, brownish-green, filmy, fern-like plant, grew in tide pools which were constantly replenished by dashing waves. Deep, shaded crevices in the reefs were lined with growths of the dark red rosettes of *Amansia glomerata*. Several species of *Galaxaura* and *Liagora* were common.

Miss Crosby carried in her collecting apron a hammer and chisel, being always on the watch for lichens, and she used frequently to work among the rocks on the hillsides while I was being entertained in the tide pools below.

Quite often we would eat a very early breakfast, get our collecting implements into one of the trunks, and prepare to take the first train for some other plantation. On the morning of June 2nd, for instance, our destination was Aiea. At ten minutes past seven we boarded the first passenger train going towards Honolulu. For a distance of eight miles the road skirts the seashore and then turns landwards or *mauka* through rice and sugar plantations, Ewa Mill, Waipahu, Pearl City. We reached Aiea at eleven minutes past eight. Like all rice fields in Hawaii, this one is worked entirely by Chinamen, they alone being able to endure the conditions of location and climate necessary for the cultivation of this cereal. On one side of the railroad track was the broad, muddy inland lake or bay of salt water, Pearl Harbor; on the other side were the terraced plots or fields, flooded to a depth of several inches with water and separated by narrow raised earthen ridges on which the careful Chinaman doubtless succeeded in walking, but which many times proved treacherous to our unsteady feet. A rice plantation, laid out as it generally is on the low flats at the foot of a valley, where mountain streams empty into the sea, is an ideal collecting ground for certain kinds of algæ. While the rice plants are growing and until they are mature, they are kept under water which is not stagnant or sour, but which flows off gradually and is constantly renewed.

The almost stagnant ponds, the sluggishly flowing streams in the ditches and the muddy banks all have their peculiar inhabitants.

The reward of the morning's work was some very interesting things. Floating in the somewhat brackish water of the outer, larger ditch, nearest the beach, were found soft, corrugated masses, bright blue-green in color, *Aphanothece prasina.* Here also were tangles of the narrow cylindrical fronds of *Enteromorpha intestinalis.* Farther back in one of the plots, among the roots of the rice plants, was an abundance of fruiting *Chara.* Living with it was the familiar and omnipresent *Hydrodictyon reticulatum.* One entire terrace, higher and somewhat drier than the others, was covered with the pale brown silky masses of *Conferva sandwicensis.* Another single plot was in the possession of *Glœothece fuscolutea*, whose soft, blue-green, gelatinous colonies floated in extensive layers on the surface of the water.

During the morning we had one of our numerous "experiences." While engaged in our work we observed a Chinaman come out of his house and begin solemnly to walk back and forth along the ridges of the field. Over his shoulder he carried a long pole to which were suspended some queer looking objects. He then set up a howling or wailing that fairly congealed our blood, so weird and uncanny were the sounds. We at once concluded that there had been a death in the Chinaman's family, and, feeling that we were intruding on his most sacred feelings, we lowered our voices to whispers and prepared to depart. At that moment another Chinaman came toward us and we tried to ask about the sad occurrence; but from his very poor English we made out that a wedding feast was being held in the first Chinaman's house, and the musical disturbance was a part of the ceremonies. We returned to our work with lightened hearts and renewed energy. Later on in the forenoon a Spanish luna talked with us, and from him we were somewhat mortified to learn that the wailing of the Chinaman was simply a common device to scare away the birds from the young rice plants.

There were many other early morning rides through sugar and rice plantations, and we frequently beheld sights that caused us to rub our eyes and suddenly ask each other if we were really experiencing this life, or only dreaming. On sugar plantations there were big irrigation ditches, sometimes flooded, sometimes dry for several days.

PLATE XV. — Wine-palms in Hilo.

Oscillatoria, *Phormidium*, *Anabæna*, *Pithophora* and *Cladophora* flourished here. While collecting in such places we were always surrounded by a crowd of onlookers, of various colors and degrees of intelligence. It was Miss Crosby's self-appointed task to interest these visitors and keep them from "bothering." In her explanations of various things she often got her hearers wild with enthusiasm, and she learned to speak "pigeon-English." The Hawaiian name for algæ was "limu," and we were therefore called the "limu ladies."

Sometimes we would all three of us go off for a stay of several days at a more distant place. We spent four days at Waikiki beach, where numerous new marine forms were picked up from the "wash." Both here and at Waianae we had many opportunities of seeing surf-riding, by native men and boys.

The surf board is shaped like an ironing board, three feet wide and nine feet long. The man swims out to smooth water, selects a wave of the right kind and mounts his board. It receives the momentum of the surf and he rides in on the surface of the water and is landed safely on the beach.

Several days were spent at the hotel at Waialua, "by the sea," and, though camping out and roughing it have their charms, we thoroughly enjoyed our stay at this place, Haleiwa, "beautiful home." We shall always remember the wide, pleasant verandas, the charming surroundings and the good times we had here. Like all Hawaiian hotels, there are cottages attached to the main structure for those who prefer them to the inside rooms. Each room is fitted with electric lights and telephone connections. It was great fun to telephone our wants to the office and then, looking out of the window, perceive a nimble Japanese servant come skipping through the grounds to attend to us, always in the politest and most satisfactory manner possible.

At one time we made a visit of ten days on a private plantation on the northeast side of Oahu, and it was with the greatest difficulty that we could make up our minds to leave it. After finishing our work in the afternoon we used to sit on the grass under the coconut trees until time to go in bathing. In the evening we had after dinner coffee on the veranda, and our host read aloud, or we talked. It certainly was anything but easy to do our regular work here. In addition to rice fields and taro patches, here were all sorts of fruit orchards, and a large number of curious introduced plants from Australia and Asia, besides an interesting family of the sacred Chinese cattle.

One day we visited the Kaliuwaa falls at the head of the valley by the same name, attended by three of the sons of our host and guided by an interesting old Hawaiian, "Jo." At first we followed the dry bed of the stream, and afterwards, reaching water, we did some difficult scrambling over stones and boulders and wading through deep holes. On our way we frequently refreshed ourselves with guavas, which are yellow on the outside like a lemon, and rose-pink on the inside, and which one eats, skin, seeds and all, and then wants more. The mountain apples were as beautiful in appearance, but are quite insipid to the taste. The algal finds consisted of a species of *Stigeoclonium* one or two feet in length; a *Scytonema* in dark reddish layers on stones in the stream. With it were tiny, blue-green cushions of a *Tolypothrix* and a *Nostoc.* When the falls were reached we were instructed by our companions to make an offering to the goddess of the waterfall, which we did in true Hawaiian style, building a tiny pile of stones on one or two large leaves, and so we made ourselves safe from falling stones, which otherwise, we were assured, would strike us. On the sides of the cliff washed by the spray of the waterfall, among mosses and liverworts, was found what seemed to be a *Nostoc*, but which turned out to be *Aphanothece nägelii.* After a hard upward scramble among *Lantana* patches and on the exceedingly slippery dried grass of the mountain side, we were taken to view a sandalwood tree, said to be the only one left on the island of Oahu. Some of the roots, twigs, berries and leaves were taken, and we also found some fine specimens of aerial roots of the screw-pine and some Ti plants.

On the 27th of June we embarked on the "Kinau" for the island of Hawaii. This voyage is compared, by those who know, to the crossing of the English channel. It is unnecessary to say that we privately relinquished all hope of seeing Paris. At certain times during this trip a kind steward is wont to visit the different staterooms and groups of people, announcing that the sea may be "a bit choppy" for the next hour or two. The unhappy passengers, whites, Japanese, Hawaiians, Chinese (and dogs), cast themselves into their berths or lie prone on the deck. It is better, however, to forget these hours.

At 11 A. M. the steamer stood off from Mahukona, and the sailors prepared to transfer the freight in small boats, used because there is no dock. Realizing that our condition would be much relieved by so doing, we induced the captain to allow us to land. It being at the time of low tide, we examined the rocks for seaweeds, and for the first time made the acquaintance of *Ahnfeltia concinna*, a succulent, brittle, brownish-red seaweed, afterwards found to grow in abundance on the rocks in Hilo harbor, at Punaluu and Pahala, therefore probably extending entirely around the island of Hawaii; though, as far as I know, not growing on the rocks of either Oahu or Kauai. Since the plant is so common along these shores, and of considerable size, it is easily distinguished by anyone enough interested to look out for it.

We found Hilo to be very delightful and quite different from Honolulu, except in the people, who were just as kind to us and made our stay with them as happy as did our friends in Oahu. As soon as we were nicely settled, we made ready for the journey to Kilauea, thirty-one miles from Hilo. The four-seated stage, drawn by four horses, was comfortable and the road as fine as the government roads in our own Yellowstone Park. Along the way, after we had reached the dense forest, many new plants were noticed. *Datura arborea*, in full bloom and fragrance, was passed. The most striking feature of the landscape was the bird's nest fern, *Asplenium nidus*, perched among the branches of the screw-pine and other trees, looking, as its name implies, like the home of some gigantic bird. Other smaller perching plants, mostly ferns, mosses and liverworts, clothed tree trunks in the greatest luxuriance. *Ophioglossum pendulum* was

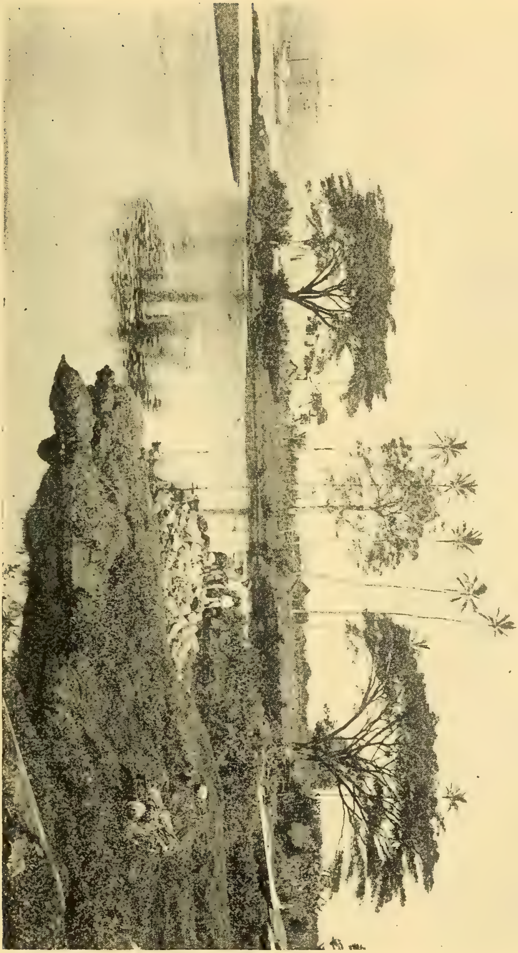


PLATE XVI. — Monkey-pod Trees, Mouth of the Waiakea River, Hawaii

collected here. This was also our first opportunity of seeing the tree ferns. The journey occupied about six hours' time. Arrived at the Volcano House, and having immediately made the four mile trip to the volcano, we turned our attention again to the algæ. It was hoped that there might be hot spring forms in the neighborhood, and, on gazing into the depths of steaming crevices, we were able to see evidence of blue-green coatings on the rocks below. But the sulphur fumes were too suggestive, and it did not seem desirable to pursue investigations further. So the only alga collected at Kilauea was a poor little undeveloped *Hormiscia*, which grew as a bright green crust on dirt and stones under dripping tanks back of the Volcano House. This is at an elevation of 4,440 feet.

On account of a runaway, I believe,

stage connection between the Volcano House and Pahala, a plantation on the south shore of the island, was interrupted. After frantic efforts to make our meaning clear through the telephone to sundry Chinese and Hawaiians in Pahala, we at last got the ear of a kind-hearted white man who promised us a team and driver to take us down. We thought our troubles ended, but the next morning found us, three women with a trunk of collecting supplies, occupying a stage drawn by a white horse and a black mule and driven by a native boy of about eighteen years. At first the road was not very bad, but inside of a few miles it became frightful, and cannot be adequately described. We were in a most ludicrous situation, had it not been so dangerous. Never were all four wheels on a level. A front wheel would pass over a large block of lava while a hind one was dragging through a deep hole, and this continued through a constant and decided decline for a distance of twenty-three miles, with variations in the sizes of holes and lava blocks. The animals were not matched in their manner, temper, or gait. The horse held back the mule pulled sturdily forward. As a result, the carriage at brief intervals swerved from the "trail," the driver always waking up just in time to back us away from some yawning precipice, while the cold perspiration stood on our brows. For more than twelve hours we clung every minute to the seats to keep from being thrown from the carriage. The jolting and shaking were terrible. To keep up our spirits we sang, even descending in our misery to "Sing this round over and over again"; but this only served to attract the attention of the driver and he paid less heed than ever to the horses. We were fortunate, indeed, to reach Pahala at nine that evening. We were very hospitably entertained here by Mr. Chong, a Chinese gentleman, who did everything possible for our comfort.

We had planned to visit Punaluu, seven miles away, on the seashore, by going on the plantation train from Pahala. Greatly to our disappointment we found that the Fourth of July celebration also included the third of July, and no trains would run. Finally, through the aid of one of our new friends, a Portuguese man was induced to take Miss Crosby and myself down at seven o'clock the next morning, on a car run by gravity. It was something like a hand car, but had only a platform, two seats and four wheels. We thoroughly enjoyed being whizzed over the high and shaky trestle-works and around sharp turns. I think the man went slower than usual, for sometimes the car stopped on an upward incline, and then he had to get out and push. If there was any danger, it did not trouble us, and we jumped off at Punaluu with our botany can and press, with a feeling as of descending from the clouds. I believe now that we would have accepted an invitation to go somewhere in a balloon, provided we were promised an opportunity for collecting algæ when we got there.

During our day at Punaluu there was but one drawback to our happiness, and the question haunted us—how were we to return to Pahala? But we managed to explore a large area of the shore, and found an interesting spring, called Kauila, long held sacred by Hawaiians, and in which we found various forms of *Conferva, Oedogonium* and *Cladophora.* With the help of a native man and woman who were able to swim out and collect algæ on a rocky point, clinging there when the waves washed over them, we got quite a few new salt-water forms. At four o'clock in the afternoon a Portuguese boy appeared on horseback, leading two saddled horses. Mr. Chong had helped us out of our dilemma in this way. However glad we were to accept his kindness, it was a case of falling from the frying pan into the fire, for at least one of us had never been on a horse's back before. Our party was soon increased by a lonely Japanese on a small nag. In this way we made the long uphill ride of seven miles, and were not thrown or killed in any other way. But Hawaiian horses do not seem to understand the American use of the reins. We were told that to hold the reins tightly would make the horse gallop, to do something else would make him trot, and so on, but we never learned what to do to make him stand still, or go to the right or to the left, or to stop standing on his hind feet. In fact, to tell the plain truth, I never dared touch the reins at all, but held on with both hands to the front of the saddle. On the contrary, I am sure that Miss Crosby *did* hold the reins, for her horse was always turning round and round, or pawing with its front feet in the air, or galloping, and when I caught up with her she would say that she was tired of walking and had just taken a little canter. We came into Pahala in the midst of the horse-racing festivities. The plantation hands had decorated the one street with their national flags and red and yellow buntings and many gay-colored lanterns, and were plunging madly back and forth on their fastest steeds. Imagine our dismay at being led through this gay scene by our two cavaliers; but there was no help for it, and one of the two horses suddenly became alive to the fact that something was going on, darted forward and ran under a low flume, thereby nearly wiping his rider from the saddle.

The next day being the "Fourth," we celebrated by walking straight from Pahala to the beach, over four miles of the roughest pahoehoe lava. As the shore rocks were steep and high, we were not able to do much collecting, but the booming of the waves was wonderful, and except that sound there was perfect silence. We felt that we were standing on a very young earth and were seeing, as it were, the first attempt

PLATE XVII. — Coconut Palms, Hilo.

of nature to cloth a new land with vegetation. The flow is quite a recent one, and one or two species of lichens, a fern and a flowering plant were the sole occupants of the bleak looking waste. The number of plants grew more and more abundant as we left the beach, but were still restricted to these few species for about two miles.

By the next morning our courage had come back, and at six o'clock we were on our way to the Volcano House with the same terrible road, driver, team and carriage as before. We had thought it impossible to take that drive again, but it was our only alternative unless we wished to remain in Pahala forever. It was really not quite so bad going up as it had been coming down. We had dinner that night at the Volcano House and at 2:30 A. M. were aroused to take the stage for Hilo. We arrived there at 10:00 o'clock in a dilapidated condition. The three sudden changes, from the dry heat of Pahala, to the icy rains of Kilauea, and then to the damp, sultry heat of Hilo, were too much for us and we were all more or less prostrated for some hours. On July 7th, we walked eight miles to and from the falls of the Waialuka river, where we found a *Lyngbya*, two *Oscillatorias*, a *Scytonema* and an *Oedogonium*.

Our next trip was along the north-east shore of Hawaii to the Waipio valley, sixty-five miles from Hilo. This time we had a comfortable two-seated carriage, a pair of good horses and a Japanese driver. The roads were in excellent condition and the scenery wonderful. This coast is made up of bold precipices, so that marine collecting had to be given up, but the conditions for the growth of fresh-water algæ were very favorable, as there is a heavy rainfall in this section, and running streams and dripping cliffs are numerous. As these rivers cast themselves into the sea from the high rock walls, beautiful cascades are formed, which can be plainly seen from the deck of the "Kinau" if one is interested in looking out. I believe that between Hilo and Waipio valley there are about ninety-seven gulches, each one causing a deviation in the road from a quarter to a half of a mile, and meaning a long downhill and a correspondingly long uphill ride on the opposite side. Our driver could *talk* absolutely no English, but he was able to swear dreadfully in English, and did so very deliberately whenever the horses balked. This occurred at the foot of each hill, presumably because it was here that he invariably applied the brake.

In the mouth of Hakalau stream a *Stigeoclonium* grew attached to pebbles. It was said that the Hawaiians used it for bait for mullet, which would bite at no other substance. Some fine desmids were also gathered from cliffs under dripping water in Hakalau gulch. Farther on, at Laupahoehoe, some dark brownish globules, *Nostoc* thalli, were picked off the mosses on wet cliffs. On these cliffs were also found a dark blue skin, a *Cylindrospermum*, and a gray slimy coating which proved to be *Glœocapsa quaternata*. At Kukuihaele, where the Pacific sugar mill is located, we made a stay of several days. From here we explored the lovely Waipio valley and the mountain streams. In a taro patch was found *Anabæna variabilis*, some *Chara* and diatoms. A memorable trip was our horseback excursion up the mountain trail to the head waters of the mill flume. My horse ran away before I was on him five minutes, and Miss Crosby's stood on his hind legs most of the time, but, partly because we were assured that they were the gentlest horses on the plantation, and mainly because we were so delighted with the wild luxuriance of ferns and mountain trees, we got the better of our first fright and did our ditch jumping and slippery climbing with comparative ease. When the horses could go no farther, they were tied, and we went afoot the rest of the way on elevated flumes—wooden ditches about two feet wide and one foot deep, some of them twenty-five feet from the ground. On the boards of the flume were attached the fronds of *Nostoc commune*, and in the falls of the stream were beds of small, black, shot-like balls, *Nostoc verrucosum*. Before going back to the horses we gathered specimens of eight or ten new ferns, among them *Psilotum triquetrum*, and some tree lobelias, shrubs three to six feet high, with very large flowers.

July 17th found us back in Hilo, and we were soon on our way to Puna district, where we wished to work in the vicinity of Green lake. The house and grounds of our host occupied the level crater of an extinct volcano, now completely carpeted with grass. In a second crater, quite near to the first, was the sheet of water known as Green lake. In this there was found to be but little except a few desmids and Cladophoras. We had heard of a warm spring in this neighborhood, and the next morning made a search for it. The water was not particularly warm, being only 31° C. at the time we took a reading, but several good things were growing in the water, and we were glad to find them. On the way back to Hilo we stopped several times to examine the shallow pools scattered about in the pahoehoe, and in most of them fine desmid material was found.

Another short excursion was made from Hilo. We were rowed in a whale-boat by four big Hawaiians down the shore a few miles to "Sekonet," where conditions were considerably different. A number of lagoons are just inside the shore line on the beach, and in these were an interesting *Monostroma* and some other forms peculiar to brackish water.

Again we consigned ourselves to the mercy of the "Kinau" and returned to Honolulu to store the collections accumulated from Hawaii. With a fresh supply of preserving cans and drying paper, but with waning ambition, we went aboard the little "James Makee," which carried us to Kealea plantation and Kapaa beach, on the island of Kauai. It being vacation time, we were given the teacher's cottage, and kept house by ourselves again. The marine flora here resembled very much that of the western shores of Oahu, and was totally different from that of Hawaii. We were able to collect again at low tide. There was an abundance of *Bryopsis*, *Caulerpa*, *Amansia* and some *Dictyota*.

Having secured a good Japanese driver and a carriage with ball-bearing wheels, we started on a journey to the most northern point of the island. The roads were in good condition, we had very pleasant weather and thoroughly enjoyed every moment of the drive. At Hanalei we collected on the coral

PLATE XVIII.—North-east Coast of Hawaii.

reef, where two species of the interesting red seaweed, *Martensia*, were secured. This had not been seen at any other point. In some rice fields there were found *Pithophora* and other Chlorophyceæ. From here we drove back to Kapaa and on south to Nawiliwili, one of the most southern points on the island. We stayed at this place all day, with nothing special to do. So we dined at a Chinaman's on mince pie, sorghum and bread, bought up all the Hawaiian fans, mats and baskets we could find, besides a quantity of polished coconut calabashes, and collected the third species of *Sargassum* known from these islands, *Sargassum polyphyllum*. After a weary wait we were picked up in the afternoon, along with a drove of sheep, and carried in a small boat two miles out to sea, where the steamer, "W. G. Hall," lay rocking frightfully.

Without going further into detail, we reached Honolulu next morning, where a few days were spent in putting away the preserved specimens in trunks, seeing to the soldering of large tin vessels and having packing boxes fitted up. It was extremely difficult to take care of the specimens preserved in formaline, which were in tin cans, for the salt in the air and water caused the tin to rust very quickly, and all vessels had to be soldered and resoldered during the time we were on the islands.

On a certain dark, rainy night at nine o'clock we said a reluctant goodbye to our kind Honolulu friends, and went out on a tugboat to the "Aorangi," up whose dark looming sides we had to climb on a swinging ladder. In two weeks more we were back in Minneapolis, arriving there on August 9th. Every tin can in the collection was leaking, yet all specimens came through in perfect condition.

We shall always look back upon our visit to the Hawaiian islands with the fondest memories. The new friends that we made are now classed among our truest ones. Entire strangers as we were, they took us into their homes and hearts. To all of them we give our deepest appreciation and gratitude.

The Distribution of Marine Algae in Japan

The Distribution of Marine Algae in Japan

K. YENDO

A glance at the map will show the islands of Japan extending like a festoon along the Asiatic coast from lat. 22° N. to lat. 51° N. The southern islands of the series are warmed by the tropical current, while the northern shores receive the cold stream from Behring sea. Accordingly the marine flora, tropical in southern Japan, changes to arctic as one travels northward.

Before entering upon the details of algal distribution, it will be well to explain the course of the prevailing ocean currents along the coast of Japan. They may be briefly described as a warm and a cold current. The warm current is the main north equatorial stream, which, turning towards the north in the vicinity of the Philippines, runs along the Loochoo islands. At the Kiushu islands, it divides into two streams, the main or eastern being known as the Japan or Black current. This runs still farther northward and northeastward to Vancouver island, on the opposite side of the Pacific ocean. It is this current which washes the east coast of the main island (Honshu) of the Japanese archipelago, running as far north as Kinkwa-san island in the summer, but in winter pushed aside by the cold stream from Behring sea, so that at this time of the year it cannot be traced farther north than Cape Inuboi.

The lesser of the two branches of the north equatorial stream is known as the Korean current. It washes the western coast of the Kiushu islands

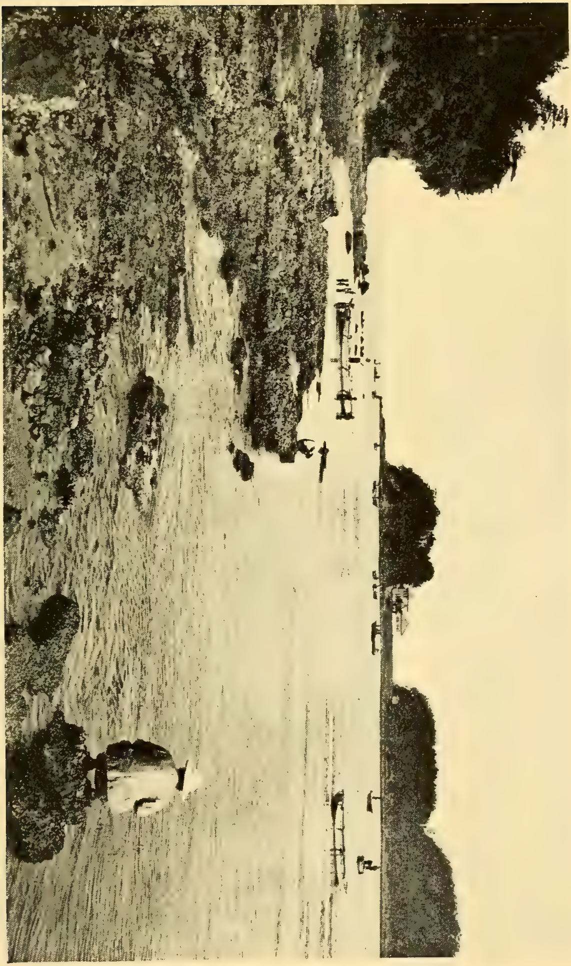


PLATE XIX. — Bay, with Marine Station in Distance.

and flows into the Japan Sea through Isushima straits. Although this branch is rather a weak stream as compared with the eastern current, it travels farther north, washing the west coast of Japan until it disappears in the sea off the northern shore of Hokkaido (Yesso).

The cold currents are originated at Kamtchatka. One of them runs southwestward along the coast of the Kurile islands, washing the southeastern coast of Yesso. Bending southward it disappears in the Pacific near Kinkwa-san island in summer, and at Cape Inuboi in winter. These two points on the coast of Japan, where the currents meet, are dreaded by mariners on account of the rough water.

Another branch of the cold current from Behring sea comes down along the west coast of Saghalin island, washing the east coast of Siberia and Korea. Of this current only a small portion touches the west coast of Yesso as an undercurrent. Thus the Japan Sea, with the tropical current on the Japanese side and the Arctic on the Siberian, shows remarkable climatic differences on the same degree of latitude. Otaru, where frosts are unknown, lies on the same parallel with Vladivostock, with its semi-arctic winter climate.

Hakodate, situated at the Sangar strait (this name is probably a corruption of Isugarn strait), between the mainland and Yesso, has an especially interesting marine flora. A branch of the eastern cold current escapes to the Japan Sea, washing the Yesso side of the strait, and the west warm current enters the same strait along the Honshu shore. It is here that I have made particular study of the algæ.

The whole algal region of Japan may be briefly divided as follows:

(*a*) Pacific side.

1. From Kurile islands to Kinkwa-san island.
2. From Kinkwa-san island to the southern end of Kiushu island.
3. From the southern end of Kiushu island to Formosa.

(*b*) Japan Sea side.

1. From Iki island to Ojika peninsula.
2. From Ojika peninsula to the north.

(*a*) *Pacific side.* 1. From Kurile islands to Kinkwa-san island.

In this region we find a subarctic flora, although a gradual change may be noted from one extremity to the other. The gigantic *Porphyra* (*Diploderma*), *Thalassiophyllum*, *Arthrotham-*

nus, *Alaria fistulosa*, etc., flourish luxuriantly on the coast of Kurile island, their southern limit being in the vicinity of Shikotan island. *Constantinea rosa-marina*, *Fucus evanescens*, *Pelvetia* (*Fucus*) *wrightii*, *Desmarestia aculeata*, *Desmarestia ligulata*, *Delesseria crassiforia*, *Delesseria serrulata*, *Odonthalia dentata*, *Agarum turneri* and many other arctic representatives come down as far south as near Hakodate. It is in this region that enormous quantities of *Laminaria* develop, a plant that is collected and dried for export to China. The *Laminariæ* of Hakodate are as luxuriant as the *Lessonia*, *Alaria* and *Nereocystis* beds of the Minnesota Seaside Station. Along the coast of Hakodate to Kinkwa-san island, *Alaria crassifolia*, several species of *Laminaria*, *Amphiroa cretacea*, *Stenogramma interrupta*, *Agarum turneri*, *Costaria turneri*, etc., reach their southern limits. Of course by no means all the important species can be mentioned in this brief account. Those that I have named are among the most notable, and will give an idea of the algal facies. That the subarctic flora is dependent upon the influence of the eastern branch of the Behring current is capable of clear demonstation.

2. From Kinkwa-san island to the southern end of Kiushu island.

In this region the district from Kinkwa-san to Cape Inuboi is for the most part sandy beach, with only a few rocky points here and there. The algal flora, so far as it is known from these two favorable spots, appears as a mixture of cold and warm current forms. This is as would be expected from the distribution of the current. A poor specimen of *Chordaria abietina* has been picked up at Cape Inuboi, but has never been seen farther south. *Undaria* (*Ulopterix*) *pinnatifida*, an important plant of the northern waters, is found in dwarfed condition in Tokyo bay. No information has been received concerning this form from regions farther south.

The rocky coast in the vicinity of the mouth of Tokyo bay is a rich and beautiful submarine garden. Both many indigenous algæ of Japan and forms of the Australian flora are known from here. This, however, is the region best studied, and in it is located the Marine Biological Station of the Imperial University of Tokyo. *Acanthopeltis japonica*, *Chondrococcus japonicus*, *Callophyllis japonica*, *Campylæphora hypnoides*, *Martensia australis*, *Prionitis angusta*, *Delisea pulchra*, *Codium mammilosum*, *Codium lindenbergii*, *Caulerpa anceps*, *Caulerpa racemosa*, *Galaxaura* *actinotrichia*, *Brachycladia australis*, *Hydroclathrus cancellatus*, several species of *Laurencia*, *Suhria japonica*, *Cystophyllum fusiforme* and many other beautiful plants are found in this vicinity. Nearly a dozen species of *Sargassum* are to be looked for here. Instead of the *Laminarias* and *Alarias*, so characteristic of the northern coast, one now finds *Ecklonia* (*E. cava* and *E. bicycles*), which, together with *Sargassum*, cover densely the sublittoral rocks. Only one *Laminaria* (*L. radicosa*) can be collected in this district.

The chain of volcanic islands which connects Bonin island with the Province of Izu enjoys a warmer climate, and the marine flora is somewhat tropical, that of the southern end of Bonin island being altogether so. The current washing some of these islands influences also the entrance of Tokyo bay and brings in some plants, such as *Boodlea coacta* and *Microdictyon.*

3. From the southern end of Kiushu island to Formosa.

Several tropical types of *Caulerpa, Galaxaura, Liagora* and *Acetabularia,* besides *Ulva reticulata, Halimeda tuna. Ceratodictyon spongioides, Vanvoorstia mirabilis, Chylospora jungermannioides, Chlorodesmis comosa, Halicoryne wrightii* are among the principal representatives of this region.

The coast of Formosa is not yet wholly studied, but a few specimens have been collected during botanical expeditions from the Imperial University of Tokyo. Judging by these, and as indicated in the reports of Heydrich, Martens and others, it is unquestionably a tropical locality.

In this region there are no gigantic forms; *Sargassum duplicatum* (?) and

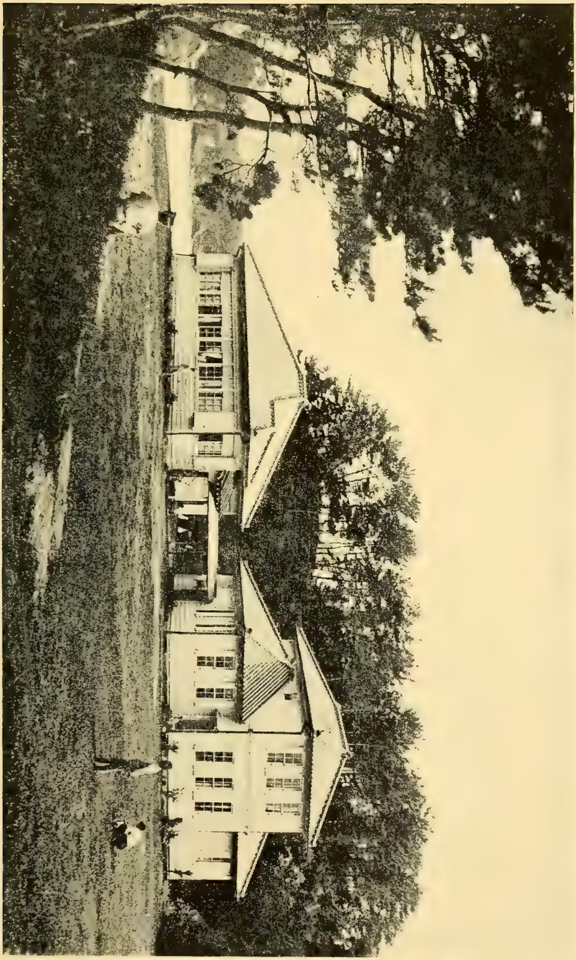


PLATE XX. — Marine Station of the University of Tokyo.

a few other species of the same genus showing the largest individuals. The flora is not poor in small and beautiful varieties, many of them being peculiar types. *Amphiroa rigida*, previously known from the Gulf of Naples only, has been collected in the southern part of Kiushu island by myself.

(*b*) *Japan Sea side.* 1. From Iki island to Ojika peninsula.

This region is washed by the minor branch of the warm current, and the flora is much influenced by it. The whole facies is of rather special character. Several species of *Sargassum*, *Codium mucronatum*, *Padina pavonia* and *Caulerpa okamurai* are also found here, as well as on the corresponding part of the Pacific coast. In general, this portion of the coast is for the most part sandy beach, and consequently poor in algæ. Such subtropical plants as are able to accommodate themselves to the comparatively cold water make up the principal population. There are several indigenous plants known from this region, but not a very large number.

2. From Ojika peninsula to the north.

This district, although influenced by the minor branch of the warm current, is dominated by the arctic stream coming down the Siberian coast, and the whole aspect of the marine vegetation is similar to that of the eastern shores of Yesso. For example, *Agarum turneri*, *Costaria turneri*, *Amphiroa cretacea* and *Pelvetia* (*Fucus*) *wrightii* may be found along the coast from the vicinity of Hakodate all the way to Saghalin island. *Laminaria* and *Alaria* also flourish here, but *Arthrothamnus*, *Thalassiophyllum* and *Constantinea* have not hitherto been reported from this side. *Fucus evanescens* and *Tichocarpus crinitus* appear luxuriantly on the coast of Rishiri island. In brief, the eastern and western coasts of Yesso are closely related to each other in respect to algal distribution. The species of *Laminaria* are abundantly developed along the entire coast, and have been particularly studied by Professor Miyabe.

One word concerning the Marine Laboratory at Misaki. It stands three miles from the fishing village of the same name at the entrance of the bay of Tokyo, and is eight hours distant from the city by steamer. There are two buildings erected, one for dormitory, the other for laboratory, purposes. The vicinity is famous for its beautiful scenery and healthful climate. On one side of the laboratory buildings are brackish coves, and on the other both sandy beach and rocky shore. The region about the station is extremely rich, both in fauna and in flora.

It is now but a few months since Rear-Admiral Beardslee paid his second visit to Japan. His first was under Commodore Perry, some half century ago, as a result of which the mysterious country was unlocked. The exact landing place was learned by some gentlemen of Tokyo from Admiral Beardslee, and they decided that there should be a monument to commemorate the event. The precise spot is very near the Marine Laboratory. It would be both pleasant and interesting for American botanists to visit Misaki and study the marine vegetation in the shadow of the monument which marks the first footprints of their forefathers who introduced American civilization to Japan.

The Kelps of Juan de Fuca

The Kelps of Juan de Fuca

CONWAY MACMILLAN

Among seaweeds the kelps include some of the largest, most widely distributed and most important forms, economically. They are technically classified among the brown algæ in the family Laminariaceæ, which comprises some twenty-five genera, seventeen of which are represented in the Straits of Fuca. Kelps occur most abundantly in the colder sea waters, and are very poorly developed, or altogether absent, in tropical oceans. In the circumpolar regions, both north and south, they find their best and most favorable habitats. Many of the genera are either monotypic or with but a limited number of species. *Alaria*, with upwards of twenty species, and *Laminaria*, with more than thirty, are the largest genera, and these are also widely distributed, some reaching the southern hemisphere. The region of the Pacific coast of North America exhibits the largest number of monotypic genera, and may with reason be considered as the most advantageous coast in the world for the study of these forms.

Most of the kelps are very large organisms, for algæ, and some of them are truly gigantic plants. One variety, *Macrocystis*, is credited with producing the longest stem of any plant in the world, measurements of a thousand feet having been reported. Another type, that of *Lessonia*, has been described by Hooker as a submarine tree, and its massive trunk and hundreds of leaf-like branches certainly convey the impression of an arboreal habit. The bladder kelp, *Nereocystis*,

PLATE XXII. — Plants of Cymathere.

reaches a length of one hundred feet at the Minnesota Seaside Station. From such large plants as these there is a gradation down to the little glove-finger shaped *Adenocystis* and the attenuated *Chorda*, no thicker than a straw. The last-named plant does not show a distinction between stipe and lamina, but the rest have a plant-body, sharply differentiated into three principal areas, the holdfast, the stipe and the lamina, while some of them, such as *Lessonia* and *Egregia*, reach a high degree of complexity through repeated bifurcations of the lamina, or through the production of innumerable outgrowths. Kelps are best developed in the sublittoral or elittoral zones, along the shore, and their bodies show remarkable structural adaptations to the different situations which they prefer. Generally speaking, kelps do not occupy positions so high upon the shore as are favorable for rockweeds (*Fucus*) or *Enteromorpha*. A long exposure at low tide is not advantageous for their growth. Thus *Postelsia*, and certain varieties of *Alaria* which grow at the highest level, select stations where they are constantly wet by the surf, and *Postelsia*, in particular, is one of the most beautifully adapted of all the surf plants. Others are covered at mid-tide, and here again the peculiarities of the different genera will be evident. *Hedophyllum*, for example, not so strongly anchored a plant, prefers quieter nooks, while *Lessonia*, with its strong trunk and firm anchorage, maintains itself in powerful surge. Still other kelps select lower levels, and are not exposed, even at low tide. Thus *Costaria* is rarely uncovered, *Pterygophora* grows on the bottom of deep tideways, and *Nereocystis* floats its bladders off shore in six fathoms of water. Indeed, each variety seems to show a preference for certain conditions of submergence, aeration, wave impact and illumination to which it is particularly adapted, and when these conditions approach the optimum one will find the species in greatest abundance and perfection.

Unlike the related rockweeds, kelps are not known to reproduce by means of sperms and eggs. The sole reproductive bodies which they form are asexual spores or gonidia, produced sometimes in large numbers, a hundred or more at a time, in microscopic sacs. These sacs, intermingled with sterile filaments, are aggregated upon special surfaces of the laminæ in patches of more or less regular shape and size. Such patches are known as sori. Sometimes they occur upon the ordinary lamina. This is the condition in *Laminaria*, *Nereocystis* and other genera. In *Pterygophora* sori do not occur upon the central lamina, but only upon the lateral pinnæ, while in *Alaria* and *Egregia* special outgrowths of the stipe known as sporophylls are produced, and these are covered by the sori. In *Pleurophycus* the soral area is limited to the midrib of the lamina.

In color the kelps are for the most part a rich olive-green. Deeply submerged portions are commonly of a lighter tint, as may be seen in the holdfasts of *Nereocystis*. Stipes are often darker and those of *Pterygophora* are almost black. Soral patches are frequently of a darker color, sometimes approaching chocolate-brown, and may easily be recognized by this character. The lamina itself is much darker in some varieties than in others. Thus the very dark olive-brown *Laminaria bongardiana* may be recognized at a distance from the lighter and more olive plants of *Hedophyllum* with which it is associated. In texture most of the kelps are leathery, and large specimens of *Laminaria* are much like great leathern aprons, hence the local name of Devil's Apron along the eastern coast of North America. The texture of *Postelsia* laminæ is, however, more like rubber, while the stipes of *Lessonia* and *Pterygophora* are like wood when fresh, and altogether horny when dry. The pinnæ of *Pterygophora*, when fresh, have the feel of thin sheets of celluloid, and the stipe of *Nereocystis* is distinctly cartilaginous.

Many of the Laminariaceæ are edible, and species of the genera *Alaria*, *Undaria* and *Laminaria* are gathered in different parts of their range for food.

The plants are also utilizable as fertilizer, and are collected for this purpose upon many coasts. The Chinese in particular use quantities of kelp for food, and bales of the dried seaweed are an important article of export from Japan.

Individual kelp plants begin their lives as microscopic spherical olive-green gonidia released in immense numbers from the myriad sacs of the soral areas. Carried about by the waves, they find lodgment in some tiny crevice of the rocks, or upon the body of some plant already established. The little sphere becomes divided by partitions, at first parallel with the substratum, and develops into an ovoid body somewhat smaller than the head of a pin and affixed by a little circular disc, known as the primitive disc. Thus at a very early age the main distinction between the holdfast on the one hand and the free portion on the other is established. As the little kelp increases in size, the distal portion becomes flattened into the lamina (except in the lower genera, such as *Chorda*), while the intermediate portion of the body remains more or less cylindrical and takes on the character of stipe. Hemispherical emergences are formed at the base of the stipe, which grow out, become forked repeatedly, and affix their ends to the substratum, thus contributing new points of anchorage for the plant as it grows larger and offers greater resistance to the surf or surge. At first the young kelps an inch or two in height look very much alike. Each plant at this stage has the appearance of a small leaflet, usually somewhat lanceolate in outline, with a short, translucent stalk, fixed by little rootlet-like outgrowths to the substratum. Some varieties retain this shape throughout their lives, reaching perhaps an enormous size. Thus *Laminaria saccharina* increases in size until the leaf is a foot wide and more than six feet in length. In others the primitive lamina becomes split in the growing region, which lies between the summit of the stipe and the base of the lamina, and the mature plant is quite different in appearance from the young form. By repeated splitting of the lamina, the hollow, massive stipe of *Postelsia*, a foot or so in height, comes to bear a tuft of a hundred or more slender, lanceolate, furrowed leaflets, giving to the plant somewhat the aspect of a miniature palm, hence its common designation as the "sea palm." Similar repeated splittings in the closely related *Nereocystis* result in the produc-

PLATE XXIII.—Rocks covered with Alaria and Hedophyllum.

tion, on the bulbous end of the stipe, of two groups of ribbon-like leaves six inches or so in width and twenty-five or thirty feet in length. In *Lessonia* the splitting results in a tree-like system of branches, the ultimate branchlets of which are produced terminally as slender, flat leaflets, and the whole plant may be six feet in length or more.

Not only by the longitudinal splitting which has been described and the subsequent growth and differentiation of the parts do the mature forms come to differ from the young in general appearance, but also in some genera by the regular production of outgrowths upon the stipe or lamina or upon both. In *Pterygophora*, for example, the young plant is of the ordinary simple unilaminate appearance, but after it has become a few inches in length outgrowths appear right and left upon the stipe below the base of the lamina, and these develop into leaf-like pinnæ reaching a length, in vigorous plants, of three or four feet. Successive pinnæ are developed in acropetal order until the plant comes to consist of a massive trunk two or three inches in diameter, bearing at the end a large tuft of ribbon-like leaves with eroded apices, only one of which, the central lamina, was originally established as such. In *Alaria* tufts of small laminæ or sporophylls are produced upon the stipe below the main leaf. In *Egregia* innumerable small outgrowths arise both upon the stipe and upon the lamina, some of those upon the stipe becoming inflated into bladders which serve to buoy up the organ, others giving rise to soral patches, while those upon the lamina contribute to the starch-making tract of the plant. When mature, the *Egregia* plant in which the process of longitudinal splitting has also gone on looks like a tuft of fringed straps, thirty or more arising from a single holdfast and prolonged twelve or fifteen feet into the water.

Another modification of the primitive leaf which should be mentioned is the perforation which takes place in laminæ of *Agarum* and *Thalassiophyllum*, so that the mature frond has the appearance of a porous plaster. *Agarum*, indeed, is known as the "sea colander" on account of this peculiarity. In *Costaria* and *Dictyoneuron* the lamina becomes strongly ribbed or reticulated, while in many of the genera the lamina, at first thin and homogeneous, becomes at an earlier or later age provided with a midrib. In some of the species the general surface of the lamina remains smooth, as in all the young forms, while in others as the plants increase in age the lamina becomes characteristically wrinkled, ribbed or furrowed. Such laminæ are beautifully displayed in *Eisenia*, *Macrocystis* and *Postelsia*.

Anatomically the kelps offer many points of special interest. At a very early age the epidermis is differentiated from the cortical tissues within, and almost as soon a distinction arises between the pith and the area surrounding it. Branches of the holdfast are not provided with pith. This area is similarly developed in stipe and lamina. Anatomically the stipe and lamina are fundamentally alike, thus indicating that they should be taken together and considered in contradistinction to the holdfast. The principal areas may be characterized briefly as follows: The epidermis is composed of

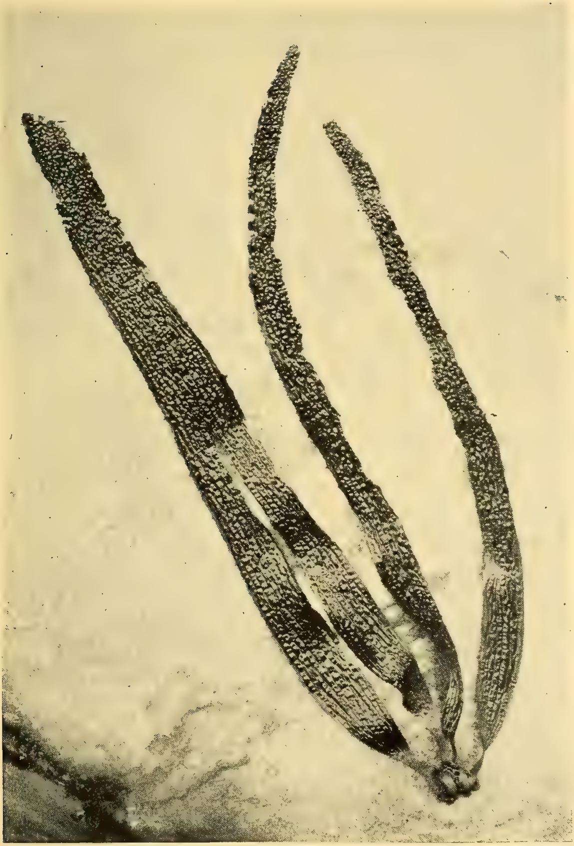


PLATE XXIV. — Plant of Dictyoneuron.

small quadrate cells with dense chromatophores. The outer cortex, comprising those layers underneath the epidermis of similar appearance with it, is distinguished from the inner cortex by the much larger cells and less copious contents of the latter. The inner cells of the inner cortex are often somewhat peculiar. Thus, in *Nereocystis* they are extended into thermometer-tube-like sieve tubes. Cells of this character are also found in *Macrocystis*. In *Pterygophora* the innermost cortical cells are sclerenchymatous. The pith is composed of a web of loosely anastomosing filaments embedded in gelatine. In bulbs of *Nereocystis*, in which the cavity is produced by the distension of the upper part of the stipe, with destruction of the pith, remnants of the pith may often be found, looking like cobwebs stretched over the inner wall of the bladder. In the pith-web many of the anastomosing tubes are joined by flaring ends. These are the so-called trumpet-hyphæ. Reserve food material is often stored in the pith.

Different genera of kelps have their anatomical peculiarities; thus, in some, mucilage ducts are formed in the cortex, while in others they are quite absent. In some, secondary thickening of the stipe occurs. This is true of perennial forms, such as *Lessonia* and *Pterygophora*. Many of the largest kelps, however, are annuals, and in these, *e. g.* in *Nereocystis*, secondary thickening will not be found. In *Lessonia* or *Pterygophora* cross sections of the stipe show rings of growth, in general appearance not unlike those of an exogenous tree. As a matter of fact they are produced in a manner peculiar to the kelp, but in so far as they are the expression of a rythmical increase in thickness, they may be compared with the growth rings of land plants. Such secondary thickening takes place in the holdfast of *Pterygophora* as well as in the stipe.

Even in the soral areas some anatomical differences can be discovered which will serve to individualize the different genera. Thus, in *Nereocystis* the cuticular lamella, which is thrown off as the epidermal cells prolong themselves into paraphyses with basal lateral spore-sacs, separates in a continuous plate and has the appearance of an exceedingly diaphanous membrane. In *Pterygophora* and *Lessonia* the cuticle under these circumstances becomes separated in the form of caps, one of which surmounts each spore sac and becomes greatly thickened. Differences, too, in the shape and size of the soral components and in the average number of gonidia seem to be constant for the different species.

Inasmuch as the same problems of maintenance confront kelps and large land plants, one is not surprised to find similar physiological tissues in both kinds of organisms. Thus both have the limiting layer, the epidermis; both the photosynthetic areas, the chlorophyll-containing cells; both the strengthening areas and skeletal apparatus, withstanding the shock of the waves in one instance and the impact of the wind in the other; both the conduction paths, the reserve tissues and the sporogenous tracts. Indeed, the conditions are not so very different after all, for land plants may be regarded as submerged in the atmospheric ocean, subject to its currents, changes in density and temperature, just as plants

PLATE XXV. — Reef with Fringe of Postelsia.

of the sea are submerged in the watery ocean.

The following genera of kelps are known to occur in the Straits of Fuca or in the immediate vicinity: *Chorda*, *Alaria*, *Agarum*, *Thalassiophyllum*, *Laminaria*, *Hedophyllum*, *Pleurophycus*, *Pterygophora*, *Eisenia*, *Cymathere*, *Costaria*, *Lessonia*, *Postelsia*, *Nereocystis*, *Dictyoneuron*, *Macrocystis* and *Egregia*. In this group all the tribes of the family are represented, and it includes forms from the simplest and lowest to the most complex and highly differentiated. It will be desirable to take up in order and briefly characterize each generic type.

Chorda. Here are included twine-shaped kelps without distinction between stipe and lamina. The lower part of the frond is solid, the upper hollow. The plant when growing resembles loose, irregular coils of heavy olive-green cord.

Alaria. The laminæ are often very long, up to fifty feet. They are provided with a strong midrib, and carry on the stipe, right and left, tufts of sporophylls. One variety at the Seaside Station is abundant upon reefs just offshore, and another is found intermingled with *Postelsia,* and growing as a surf plant.

Agarum. The broad leaves of *Agarum* are provided with a distinct midrib, and are perforated with large numbers of circular or elliptical holes.

Thalassiophyllum. In the matter of perforations the plants classified here resemble *Agarum*, but there is no midrib, and the leaf is somewhat one-sided in appearance.

Laminaria. The frond is broadly leaf-like, without perforations, lateral outgrowths or distinct midrib. There is a well-marked stipe, and the sori are somewhat irregularly disposed upon the surface of the leaf.

Hedophyllum. The leaves are almost sessile upon the holdfast, and spread out like those of a cabbage. Otherwise the plants closely resemble the type of *Laminaria.*

Pleurophycus. Here is classified a *Laminaria*-like plant with wrinkled leaf and strong, wide, strap-like midrib, upon which the sori are produced.

Pterygophora. This is a perennial plant, the stipe of which becomes very strong and massive, and shows distinct rings of growth. At the tip is borne a single leaf with indistinct midrib and eroded tip. Springing from the stipe below this terminal lamina are numerous ribbon-like leaves with rounded ends, without midribs, and with irregular sori basally disposed.

Eisenia. The short, stout stipe is forked, and each division bears terminally a tuft of wrinkled, serrate leaves a foot or more in length. The general habit of the plant is much like that of *Postelsia*, from which it can be distinguished by the strong forking of the stem and the much greater size and length of the leaflets.

Cymathere. From a small, disc-shaped holdfast, springs a long, slender, ribbon-like lamina with short stipe and a triplicate longitudinal fold along the middle.

Costaria. The leaves are broad, very much wrinkled and often perforate. There are commonly five strong longitudinal ribs, three of which are prominent on the upper surface and two on the lower.

PLATE XXVI. — Plants of Alaria.

Lessonia. The stipe is very strong and massive and is repeatedly forked into branches and branchlets. Each ultimate branchlet carries a slender, elongated lamina, some of which are provided with midribs, others without.

Postelsia. From a strong holdfast rises a tubular stipe a foot or so in height, upon the end of which is borne two close tufts of slender wrinkled laminæ up to three or four inches in length, or even more. The plant is characteristically a surf plant.

Nereocystis. The general habit is something like that of *Eisenia* and *Postelsia*, but the stipes grow to a great length in the deeper waters offshore, becoming swollen at the summit into bladders, or pneumatocysts, sometimes six inches in diameter. Upon the top of the bladder, ribbon-like leaves often several yards in length are produced in two tufts.

Dictyoneuron. A peculiarity of this genus is the gradual dying away of the stipe, which, however, forks repeatedly, separating the laminæ, which are reticulated somewhat as in *Costaria*, but much slenderer.

Macrocystis. From the strong holdfast arises commonly a stipe which forks once or more in the ordinary manner, but all subsequent splittings of the lamina are one-sided, giving rise to extremely long (up to a thousand feet), rope-like branches, at regular intervals, upon which are borne the wrinkled laminæ, each provided with a pneumatocyst at its base.

Egregia. This plant, which is the highest of the kelps, produces, from its strong holdfast, short, forked stipes, which are prolonged into slender, strap-shaped ultimate branches, upon the tips of which the wrinkled laminæ are borne, not at first clearly to be distinguished from the strap-shaped stipe. Great numbers of lateral outgrowths are produced, those upon the stipe being many of them developed as swimming bladders, or as sporophylls, while those upon the margins of the lamina neither become swollen nor give rise to sori.

Of the preceding genera *Eisenia* is perhaps the least abundant in the Straits of Fuca. Specimens have been reported, however, from the Sound, and fragments ascribed to this genus were collected during the winter of 1901 near Victoria. *Thalassiophyllum* does not seem to be particularly abundant, and only a few specimens of *Chorda* have been seen from this locality. The others are all decidedly abundant, and the more highly organized forms, such as *Lessonia*, *Postelsia*, *Macrocystis* and *Egregia*, are everywhere displayed in their special habitats. Few groups of plants are more admirable as objects of study than the kelps, for not only are they interesting in themselves, but they illustrate with extraordinary clearness and simplicity many of the important laws of structure, function, adaptation and geographical distribution. Situated as it is, the Minnesota Seaside Station should become a center for the investigation of these remarkable organisms of the sea.

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